DIVISION OF BIOLOGICAL SCIENCES

The Division of Biological Sciences provides a unified curriculum for undergraduate majors enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. Courses in biological sciences are integral to many disciplines and are basic requirements in many schools and colleges at Cornell.

Graduate study in the biological sciences is administered by more than a dozen specialized fields within the Graduate School, as described in the Announcement of the Graduate School.

ORGANIZATION

The Division of Biological Sciences is composed of six major sections: Biochemistry, Molecular and Cell Biology; Ecology and Systematics; Genetics and Development; Neurobiology and Behavior; Physiology; Plant Biology; and, in addition, the L. H. Bailey Hortorium and the Shoals Marine Laboratory.

The offices, research laboratories, and classrooms of biology faculty members are located in many different buildings on the campus, primarily in the Colleges of Agriculture and Life Sciences, Arts and Sciences, and Veterinary Medicine.

Student services are provided by the division's Office for Academic Affairs and the Behrman Biology Center, both located in Stimson Hall, where academic advice, information on biological sciences course offerings, other important information, and counseling are available for undergraduates. The Office for Academic Affairs also follows the progress of biology majors and works closely with faculty advisers. Additional services and resources of the Biology Center include academic program planning, tutoring, lecture tapes, examination files, and information on undergraduate research opportunities. The center has comfortable areas for studying and relaxing.

The Shoals Marine Laboratory, a cooperative venture with the University of New Hampshire, is located on Appledore Island in the Gulf of Maine. Its base office in Stimson Hall provides advising and career counseling for students interested in the marine sciences and administers the SEA Semester program for Cornell students pursuing studies at Woods Hole or aboard the schooner *Westward* or brigantine *Corwith Cramer.*

FACULTY

P. J. Bruns, director; H. T. Stinson, associate director; K. K. Adler, C. F. Aquadro, W. J. Arion, R. Barker, A. H. Bass, D. M. Bates, B. L. Bedford, A. Bensadoun, E. N. Bergman, K. W. Beyenbach, A. W. Blackler, S. E. Bloom, R. Booker, A. C. Borror, A. P. Bretscher, W. J. Brown, W. L. Brown, W. R. Butler, J. M. Calvo, R. R. Capranica, B. F. Chabot, J. L. Cisne, R. A. Corradino, W. B. Currie, P. J. Davies, J. I. Davis, A. Dobson, J. J. Doyle, T. Eisner, S. T. Emlen, P. P. Feeny, G. W. Feigenson, R. H. Foote, J. E. Fortune, T. D. Fox, J. Gibson, Q. H. Gibson, R. F. Gilmour, M. L. Goldberg, N. G. Hairston, B. P. Halpern, O. P. Hamill, W. Hansel, M. R. Hanson, R. G. Harrison, R. M. Harris-Warrick, C. D. Harvell, L. A. Heppel, G. P. Hess, P. C. Hinkle, C. D. Hopkins, K. A. Houpt, T. R. Houpt, R. W. Howarth, S. H. Howell, H. C. Howland, R. R. Hoy, T. C. Huffaker, A. T. Jagendorf, P. A. Karplus, M. N. Kazarinoff, E. B. Keller, K. J. Kemphues, K. A. R. Kennedy, L. V. Kochian, R. P. Korf, T. A. LaRue, A. C. Leopold, S. A. Levin, G. E. Likens, J. T. Lis, E. R. Loew, M. A. Luckow, R. E. McCarty, D. K. McClearn, A. R. McCune, J. M. Fessenden MacDonald, R. J. MacIntyre, W. H. Mark, P. L. Marks, J. K. Moffat, J. B. Nasrallah, K. J. Niklas, K. C. Nixon, T. G. Owens, D. J. Paolillo, M. V. Parthasarathy, D. Pimentel, T. R. Podleski, F. H. Pough, A. G. Power, W. B. Provine, A. Quaroni, E. Racker, E. Adkins Regan, M. E. Richmond, J. W. Roberts, D. Robertshaw, R. B. Root, M. M. Salpeter, A. M. Schneiderman, T. D. Seeley, P. W. Sherman, R. F. Silver, R. M. Spanswick, I. A. Tamas, D. N. Tapper, J. F. Thompson, R. Turgeon, B.-K. Tye, S. Via, V. M. Vogt, C. Walcott, R. H. Wasserman, M. Watford, R. O. Wayne, W. W. Webb, N. F. Weeden, Q. D. Wheeler, D. B. Wilson, D. W. Winkler, M. F. Wolfner, J. F. Wootton, R. Wu, D. A. Young, S. A. Zahler, D. B. Zilversmit

Other Teaching Personnel

G. Albrecht, R. R. Alexander, R. A. Calvo, C. Eberhard, P. R. Ecklund, M. F. Ferger, J. C. Glase, J. M. Griffiths, J. B. Heiser, C. H. McFadden, H. C. Reiss

DISTRIBUTION REQUIREMENT

In the College of Agriculture and Life Sciences, the biological sciences distribution requirement (Group B) is for a minimum of 9 credits, including at least 6 credits of introductory biology satisfied by Biological Sciences 109–110,105–106, or 101 and 103 plus 102 and 104, or 107–108. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) satisfies the requirement for introductory biology. The additional credits may be satisfied by any biological sciences courses except Biological Sciences 152, 200, 202, 205, 206, 301, or 367.

In the College of Arts and Sciences, the biological sciences distribution requirement is for a two-semester introductory biology sequence selected from Biological Sciences 109–110,105–106, or 101 and 103 plus 102 and 104, or 107–108. An Advanced Placement score of 4 or 5 fulfills one-half the distribution requirement. Students must taken an upper-level biology course to complete the distribution requirement in biological sciences.

In the College of Human Ecology, the natural sciences distribution requirement is for at least 6 credits selected from Biological Sciences 109–110, 101 and 103 plus 102 and 104, 105–106 or 107–108 or from specified courses in chemistry or physics. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) also satisfies the distribution requirement in the natural sciences.

Note: Biological Sciences 101–102–103–104 should be taken as a unit by students of any college except those with advanced placement credit.

Switching from one introductory biology sequence to another at midyear may *not* be possible because of variation in presentation of topics. Students must receive permission of the instructor to switch sequences. Taking sequences in reverse or inconsecutive order is strongly discouraged.

THE MAJOR

The Division of Biological Sciences offers a major in biological sciences to students enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. The undergraduate program is coordinated for students in both colleges through the division's Office for Academic Affairs, where students submit their applications to the major and obtain biology faculty advisers.

During the second semester of the sophomore year, all students who intend to major in biological sciences must apply for acceptance into the major with the associate director for academic affairs, in 118 Stimson Hall. Students in the College of Agriculture and Life Sciences who were admitted directly to the major complete the application process to declare a concentration area and to assure satisfactory progress toward completion of the major. Acceptance into the major requires completion of the course sequences in introductory biology, chemistry, and mathematics (see requirements 1–3 below), plus one semester of organic chemistry lectures. In addition, a 2.75 Cornell cumulative grade-point average is required for final acceptance into the major except for those students admitted directly to the major as freshmen (College of Agriculture and Life Sciences students only) or as transfers. Students in the process of completing these prerequisites for admission to the major may be accepted on a *provisional* basis. Final acceptance into the major is required for graduation with a biological sciences major. It is the student's responsibility to assure that final acceptance has been granted.

Whenever possible, students should include the introductory biology, chemistry, and mathematics sequences in their freshman schedule and complete the organic chemistry lecture course in their sophomore year. Students are not encouraged to continue with the major in biological sciences unless

performance in these four subjects gives evidence of capacity to perform satisfactorily at a more advanced level.

Students who matriculated *before* fall 1988 must complete the major by satisfying the requirements listed below. Students who matriculated fall 1988 and after see changes in the Requirements for the Major. These courses should be taken for a letter grade unless the course is offered for S-U grades only.

1) *Introductory biology for majors* (one year): Biological Sciences 101 and 103 plus 102 and 104, or 105–106. Biological Sciences 107–108, offered during the eight-week Cornell Summer Session for 8 credits, also satisfies the introductory biology requirement for majors. Students may choose to accept advanced placement if they have received a score of 5 on the Advanced Placement Examination of the College Entrance Examination Board (CEEB). Students with a score of 4 must fulfill the introductory biology requirement by taking Biological Sciences 101–102, 101 and 103, 102 and 104, or 103–104. These students should consult information available in the course office (1140 Comstock Hall) and in the Biology Center (G20 Stimson Hall) to determine which semester to take to complete the introductory biology requirement. Students in doubt are advised to take Biological Sciences 101 and 103. These students receive a total of 8 introductory biology credits (4 AP credits plus 4 course credits).
2) **General chemistry** (one year): Chemistry 207–208,* or 215–216,* or 103–104.
3) **College mathematics** (one year, including at least one semester of calculus): Mathematics 111–112,* 105–106, or 111–105. Education 115 may *not* be used to fulfill any part of this requirement.
4) **Organic chemistry:** Chemistry 253 and 251, or 253 and 301, or 357–358 and 251, or 357–358 and 301, or 359–360 and 251, or 359–360 and 301.
5) **Physics:** Physics 207–208,* 112–213,* or 101–102. Those who take Physics 112–213 are advised to complete Physics 214 as well.
6) **Genetics:** Biological Sciences 281.
7) **Biochemistry:** Biological Sciences 330 or 331.
8) **A concentration area** selected from the outline below.
9) **Breadth in biology**, as described below.
10) **Foreign language:** students registered in the College of Agriculture and Life Sciences must satisfy the foreign language requirement of the Division of Biological Sciences by (a) presenting evidence of successful completion of three or more years of study of a foreign language in high school or (b) attaining a score of 560 or more on the reading portion of the College Entrance Examination Board achievement test or (c) achieving "qualification" status in a language as defined by the College of Arts and Sciences or (d) successfully completing at least 6 college credits in a foreign language. Students registered in the College of Arts and Sciences must satisfy the language requirement as stated by that college.

*Since modern biology has an important physical and quantitative orientation, students are advised to undertake basic science courses that emphasize this approach. Asterisks in the above list indicate the courses that provide this orientation, but *all* courses listed are acceptable.

Although not required for the biological sciences major, a course in statistics is recommended for students planning graduate study or a research career. Students should consult their faculty advisers when choosing appropriate courses in statistics.

As an alternative to requirements 8 and 9 above, students may choose to complete the Program in General Biology, outlined below.

Concentration Areas and Requirements

As noted in the list of requirements above, students accepted into the biological sciences major must choose a concentration area or the Program in General Biology. The concentration requirements are designed to help students achieve depth in one area of biology while ensuring that the selected advanced courses form a coherent and meaningful unit. Because of the flexibility allowed in satisfying these requirements, students should consult their faculty advisers. The possible concentration areas are listed below.

1) *Animal Physiology and Anatomy:* Bio S 316, Cellular Physiology; Bio S 311 and 319, Introductory Animal Physiology, Lectures and Laboratory; and at least one additional course selected from the following: Bio S 313, Histology: The Biology of the Tissues; Bio S 385, Developmental Biology; Bio S 389, Embryology; Bio S 458, Mammalian Physiology; Bio S 492, Sensory Function; An Sc 427, Fundamentals of Endocrinology.

Note: Bio S 313, Histology: The Biology of the Tissues, is recommended for those students who have not yet taken Bio S 274, The Vertebrates, as part of their concentration requirements in animal physiology and anatomy. Students should contact their adviser for other possible alternatives.

2) *Biochemistry:* Chemistry 300 or 215–216, Quantitative Chemistry, must be taken. One of the following organic chemistry laboratory sequences must also be taken: Chemistry 301–302 or 251–252 and 302 or 301 or 251–252. In addition, students must take a physical chemistry sequence (Chemistry 389–390 or 287–288.1 or 287–288.2) and a biochemistry laboratory course (Bio S 638 or 430 or 630). Note that Physical Chemistry 288.2 is designed for biologists, but either sequence is appropriate. It is recommended that students take the more rigorous organic chemistry and physics sequences (Chemistry 357–358 or 359–360 and Physics 207–208) and a third semester of calculus.

   Students interested in biochemistry should complete a year of introductory chemistry other than Chemistry 103–104 before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year.
3) *Botany:* courses chosen with the aid of an adviser to meet the goal of exposing each student to plant structure, function, classification, ecology, and evolution. Three courses, one from each of the three following categories, fulfill the minimum requirements. Students are encouraged to begin the sequence of courses with Bio S 241 (see category b): (a) Bio S 242 and 244 or Bio S 341 and 349, Plant Physiology, Lectures and Laboratory; (b) Bio S 241, Introductory Botany; Bio S 248, Taxonomy of Vascular Plants; Bio S 448, Plant Evolution and the Fossil Record; or Pl Pa 309, Introductory Mycology; and (c) Bio S 345, Plant Anatomy; or Pl Pa 301, Introductory Plant Pathology. Students interested in a broad background in botany are encouraged to take Bio S 346, Algal Physiology; Bio S 463 and 465, Plant Ecology, Lectures and Laboratory; and additional courses in (b) and (c).
4) *Cell Biology:* Chemistry 300 or 215–216, Quantitative Chemistry; Bio S 630, Laboratory in Cell Biology (strongly recommended), Bio S 638, Intermediate Biochemical Methods, or Bio S 430, Basic Biochemical Methods; and one of the following two options:

Option 1: Bio S 432, Survey of Cell Biology, and 8 additional credits distributed between groups A and B and approved by the adviser.

Option 2: The two courses from Group A and 6 additional credits from Group B approved by the adviser.

Group A: Bio S 438, Cell Proliferation and Oncogenic Viruses; Bio S 483, Molecular Aspects of Development.

Group B: Bio S 222, Neurobiology and Behavior II: Introduction to Neurobiology; Bio S 305, Basic Immunology, Lectures; Bio S 307, Basic Immunology, Laboratory; Bio S 313, Histology: The Biology of the Tissues; Bio S 345, Plant Anatomy; Bio S 485, Microbial Genetics, Lectures; Bio S 486, Immunogenetics; An Sc 419, Animal Cytogenetics; Micro 290, General Microbiology Lectures; Micro 291, General Microbiology Laboratory; Micro 484, Cytology of Prokaryotes Lectures; Micro 485, Cytology of Prokaryotes Laboratory.

Students interested in cell biology should complete a year of introductory chemistry other than Chemistry 103–104 before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year.

Students anticipating graduate work in cell biology should consider taking a physical chemistry sequence (Chemistry 389–390 or 287–288.1 or 287–288.2). Note that Physical Chemistry 288.2 is designed for biologists, but either sequence is appropriate.

5) *Ecology, Systematics, and Evolution:* Bio S 261, Principles of Ecology; Bio S 378, Evolutionary Biology; and at least two of the following courses or one of the following courses and a 400–level, 4–credit course offered at Shoals Marine Laboratory: Bio S 248, Taxonomy of Vascular Plants; Bio S 373, The Invertebrates: Form, Function, and Evolution; Bio S 455, Insect Ecology; Bio S 457/459 (462/464), Limnology; Bio S 461, Population and Evolutionary Ecology; Bio S 462, Marine Ecology; Bio S 463/465, Plant Ecology; Bio S 464, Microevolution and Macroevolution; Bio S 471, Mammalogy; Bio S 472 (473), Herpetology; Bio S 475, Ornithology; Bio S 476, Biology of Fishes; Bio S 478, Ecosystem Biology; Bio S 479 Paleobiology; Bio S 481 Population

Genetics; Bio S 484, Molecular Evolution. Students are encouraged to gain experience in some aspect of field biology through course work at a biological field station or work experience.

6) *Genetics and Development:* 9 credits, usually selected from the following courses: Bio S 378, Evolutionary Biology; Bio S 385, Developmental Biology; Bio S 389, Embryology; Bio S 481, Population Genetics; Bio S 482, Human Genetics and Society; Bio S 483, Molecular Aspects of Development; Bio S 484, Molecular Evolution; Bio S 485 and 487, Microbial Genetics; Bio S 486, Immunogenetics; Bio S 633, Biosynthesis of Macromolecules; Bio S 639, The Nucleus; Bio S 641, Laboratory in Plant Molecular Biology; Bio S 644, Plant Growth and Development; Bio S 653, Plant Molecular Genetics; Bio S 688, Yeast Genetics; An Sc 419, Animal Cytogenetics.

7) *Neurobiology and Behavior:* The two-semester introductory course sequence, Neurobiology and Behavior I and II (Bio S 221 and 222) with discussion section (4 credits per term), and 9 additional credits, among which must be a course from the neurobiology and behavior offerings. Bio S 420, 498, 499, and 720 may *not* be used as this neurobiology and behavior course. The remainder of the 9 credits may be in any course (such as physiology, developmental biology, cellular biology, ecology, vertebrate or invertebrate biology, or neurobiology and behavior) approved by the adviser. Courses used to fulfill the concentration requirements may *not* be counted toward fulfillment of the breadth requirement.

Note: Students who declare the concentration in neurobiology and behavior after taking Bio S 221 or 222 for only 3 credits must complete additional course work in neurobiology and behavior. These students should consult the chair of the Section of Neurobiology and Behavior (W119 Seeley G. Mudd Hall) to determine what course(s) to use to make up the deficiency.

8) *Independent Option:* Special programs for students interested in biophysics, microbiology (College of Arts and Sciences students only), or nutrition are available under this option. In addition, students who want to undertake a course of study not covered by the seven existing concentration areas, special programs, or the Program in General Biology may petition the Division of Biological Sciences Curriculum Committee. Information on independent options and Curriculum Committee petition forms are available in the Office for Academic Affairs, 118 Stimson Hall.

Requirement for Breadth in Biology

To fulfill the requirement for breadth in biology, students must pass a total of two courses outside of their concentration area selected from two of the categories listed below.

Students should consult their faculty advisers, keeping in mind the following rules, when choosing the courses to meet this requirement. A course may not count for breadth if it *could* be used (even if it is not) to fulfill a concentration requirement (see note below). No course may be used to fulfill the breadth requirement if it is also used to fulfill a concentration requirement. Students may not count two courses for breadth credit if one course is a prerequisite to the other course. Students concentrating in animal physiology and anatomy; botany; cell biology; ecology, systematics, and evolution; or genetics and development should see the notes following the list of approved breadth courses.

1) *Animal Physiology and Anatomy:* Biological Sciences 214, 311, 313; Nutritional Sciences 331.

2) *Botany:* Biological Sciences 241, 242 and 244, 248, 341 and 349, 343, 345, 441, 448; Plant Pathology 309.

3) *Cellular Biology:* Biological Sciences 305, 316, 432; Microbiology 290.

4) *Developmental Biology:* Biological Sciences 385, 389, 483; Animal Science 220.

5) *Ecology, Systematics, and Evolution:* Biological Sciences 261, 378.

6) *Neurobiology and Behavior:* Biological Sciences 221, 222.

Note: Students concentrating in animal physiology and anatomy may not use Biological Sciences 316, 385, 389, or 432 to fulfill the breadth requirement.

Students concentrating in cell biology may not use Biological Sciences 222, 313, 345, or 483 to fulfill the breadth requirement.

Students concentrating in ecology, systematics, and evolution may not use Biological Sciences 248 to fulfill the breadth requirement.

Students concentrating in genetics and development may not use Biological Sciences 378 or any course in group 4 to fulfill the breadth requirement.

Program in General Biology

As an alternative to the requirements for a concentration area and for breadth in biology, students may choose to complete the Program in General Biology. These students must fulfill *all* other requirements for the biological sciences major. In addition, students must complete the following:

1) Ecology (Bio S 261 or Bio S 262 [no longer offered]).

2) Neurobiology and Behavior I or II (Bio S 221 or 222).

3) A physiology course from the following: Bio S 242 and 244, or 341 and 349, Plant Physiology; Bio S 311, Introductory Animal Physiology, Lectures.

4) One course from the following: Bio S 241, Introductory Botany; Bio S 248, Taxonomy of Vascular Plants; Bio S 274, Functional and Comparative Morphology of Vertebrates; Entom 212, Insect Biology; Micro 290 and 291, General Microbiology.

5) At least one course offered by the Division of Biological Sciences concentrating on plants. This may be satisfied by a course that also fulfills requirement 3 or 4.

6) At least one course offered by the Division of Biological Sciences with a laboratory. This may be satisfied by a course that also fulfills requirement 3, 4, or 5.

7) A biological sciences course offered for 2 or more credits having as a prerequisite one of the following: Bio S 221, Neurobiology and Behavior I; Bio S 222, Neurobiology and Behavior II; Bio S 241, Introductory Botany; Bio S 242 or 341, Plant Physiology; Bio S 261, Principles of Ecology; Bio S 274, Functional and Comparative Morphology of Vertebrates; Bio S 281, Genetics; Bio S 311, Introductory Animal Physiology, Lectures; Bio S 330 or 331, Principles of Biochemistry.

Changes in the Requirements for the Major

Beginning with students who matriculated in fall 1988, the requirements for the major in biological sciences have been modified as follows: (1) a course in evolutionary biology (Bio S 378) is required for all majors; (2) the biology breadth requirement is eliminated; (3) the present areas of concentration are now called programs of study (the requirements for each program of study allow completion of the program of study with 13–15 course credits); (4) the requirements for satisfying the program in general biology have been changed and now constitute a program of study in general biology. The specific descriptions of the programs of study are listed below. These courses should be taken for a letter grade unless the course is offered for S-U grades only.

1) **Introductory biology for majors** (one year): Biological Sciences 101 and 103 plus 102 and 104, or 105–106. Biological Sciences 107–108, offered during the eight-week Cornell Summer Session for 8 credits, also satisfies the introductory biology requirement for majors. Students may choose to accept advanced placement if they have received a score of 5 on the Advanced Placement Examination of the College Entrance Examination Board (CEEB). Students with a score of 4 must fulfill the introductory biology requirement by taking Biological Sciences 101–102, 101 and 103, 102 and 104, or 103–104. These students should consult information available in the course office (1140 Comstock Hall) and in the Biology Center (G20 Stimson Hall) to determine which semester to take to complete the introductory biology requirement. For students in doubt, Biological Sciences 101 and 103 is advised. These students receive a total of 8 introductory biology credits (4 AP credits plus 4 course credits).

2) **General chemistry** (one year): Chemistry 207–208,* or 215–216,* or 103–104.

3) **College mathematics** (one year, including at least one semester of calculus): Mathematics 111–112,* 105–106, or 111–105. Education 115 may not be used to fulfill any part of this requirement.

4) **Organic chemistry:** Chemistry 253 and 251, or 253 and 301, or 357–358 and 251, or 357–358 and 301, or 359–360 and 251, or 359–360 and 301.

5) **Physics:** Physics 207–208,* 112–213,* or 101–102. Those who take Physics 112–213 are advised to complete Physics 214 as well.

6) **Genetics:** Biological Sciences 281.

7) **Biochemistry:** Biological Sciences 330 or 331.

8) **Evolutionary Biology:** Biological Sciences 378.

9) **A program of study** selected from the outline below.

10) **Foreign language:** students registered in the College of Agriculture and Life Sciences must satisfy the foreign language requirement of the Division of Biological Sciences by (a) presenting evidence of successful completion of three or more years of study of a foreign language in high school or (b) attaining a score of 560 or more on the reading portion of the College Entrance Examination Board achievement test or (c) achieving "qualification" status in a language as defined by the College of Arts and Sciences or (d) successfully completing at least 6 college credits in a foreign language. Students registered in the College of Arts and Sciences must satisfy the language requirement as stated by that college.

*Since modern biology has an important physical and quantitative orientation, students are advised to undertake basic science courses that emphasize this approach. Asterisks in the above list indicate the courses that provide this orientation, but *all* courses listed are acceptable.

Although not required for the biological sciences major, a course in statistics is recommended for students planning graduate study or a research career. Students should consult their faculty advisers when choosing appropriate courses in statistics.

Programs of Study Requirements

As noted in the list of requirements above, students accepted into the biological sciences major must choose a program of study. The program of study requirements are designed to help students achieve depth in one area of biology while ensuring that the selected advanced courses form a coherent and meaningful unit. Because of the flexibility allowed in satisfying these requirements, students should consult their faculty advisers. The possible programs of study are listed below.

1) *Animal Physiology and Anatomy:* Bio S 311 and 319, Introductory Animal Physiology, Lectures and Laboratory; Bio S 313, Histology: The Biology of Tissues; and Bio S 316, Cellular Physiology.

2) *Biochemistry:* Chemistry 300 or 215–216, Quantitative Chemistry, must be taken. One of the following organic chemistry laboratory sequences must also be taken: Chemistry 301–302 or 251–252–302 or 301 or 251–252. In addition, students must take a physical chemistry sequence (Chemistry 389–390 or 287–288.1 or 287–288.2) and a biochemistry laboratory course (Bio S 638 or 430 or 630). Note that Physical Chemistry 288.2 is designed for biologists, but either sequence is appropriate. It is recommended that students take the more rigorous organic chemistry and physics sequences (Chemistry 357–358 or 359–360 and Physics 207–208) and a third semester of calculus. Students interested in biochemistry should complete a year of introductory chemistry other than Chemistry 103–104 before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year.

3) *Botany:* A minimum of 13 credits is required from courses chosen with the aid of an adviser to meet the goal of exposing each student to plant structure, function, classification, ecology, and evolution. Three courses, one from each of the three following categories, fulfill the minimum requirements. Students are encouraged to begin the sequence of courses with Bio S 241 (see category b): (a) Bio S 242 and 244 or Bio S 341 and 349, Plant Physiology, Lectures and Laboratory; (b) Bio S 241, Introductory Botany; Bio S 248, Taxonomy of Vascular Plants; Bio S 448, Plant Evolution and the Fossil Record; or Pl Pa 309, Introductory Mycology; and (c) Bio S 345, Plant Anatomy; or Pl Pa 301, Introductory Plant Pathology. Students interested in a broad background in botany are encouraged to take Bio S 346, Algal Physiology; Bio S 463 and 465, Plant Ecology, Lectures and Laboratory; and additional courses in (b) and (c).

4) *Cell Biology:* Chemistry 300 or 215–216, Quantitative Chemistry; Bio S 432, Survey of Cell Biology; Bio S 630, Laboratory in Cell Biology (strongly recommended), **or** Bio S 638, Intermediate Biochemical Methods **or** Bio S 430, Basic Biochemical Methods; **and** at least 5 additional credits chosen from the following courses: Bio S 222, Neurobiology and Behavior II: Introduction to Neurobiology; Bio S 305, Basic Immunology; Bio S 313, Histology: The Biology of the Tissues; Bio S 345, Plant Anatomy; Bio S 435–436, Undergraduate Biochemistry Seminar; Bio S 438, Cell Proliferation and Oncogenic Viruses; Bio S 483, Molecular Aspects of Development; Bio S 444, Plant Cell Biology; Bio S 636, Current Topics in Cell Biology; Bio S 639, The Nucleus; An S 419, Animal Cytogenetics.

   Students interested in cell biology should complete a year of introductory chemistry other than Chemistry 103–104 before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year. If graduate work in cell biology is anticipated, students should consider taking a physical chemistry sequence (Chemistry 389–390 or 287–288.1 or 287–288.2).

5) *Ecology and Systematics:* Bio S 261, General Ecology, and 10 credits from the following course lists, including at least one course from each group:

   (a) Bio S 241, Introductory Botany; Bio S 274, Functional and Comparative Morphology of Vertebrates; Bio S 373, The Invertebrates: Form, Function, and Evolution; Bio S 471, Mammalogy; Bio S 472, Herpetology; Bio S 475, Ornithology; Bio S 476, Biology of Fishes; Entom 212, Insect Biology.

   (b) Bio S 263, Field Ecology; Bio S 272, Functional Ecology; Bio S 448, Plant Evolution and the Fossil Record; Bio S 455, Insect Ecology; Bio S 457 and 459, Limnology, Lectures and Laboratory, Bio S 461, Population and Evolutionary Ecology; Bio S 462, Marine Ecology; Bio S 463 and 465, Plant Ecology, Lectures and Laboratory; Bio S 464, Microevolution and Macroevolution; Bio Sci 470, Ecological Genetics; Bio S 478, Ecosystem Biology; Bio S 479, Paleobiology; Bio S 481, Population Genetics.

   One 400-level, 4-credit course offered at Shoals Marine Laboratory may be applied toward the 10 credits. Students are encouraged to gain experience in some aspect of field biology through course work at a biological field station or work experience.

6) *General Biology:* The program of study in general biology requires a minimum of 13 credit hours from courses offered by the Division of Biological Sciences and may include Microbiology 290–291. These credits must include one course from the courses listed for at least three of the seven other programs of study, and must include a course with a laboratory and a minimum of two upper-level (300 and above) courses.

7) *Genetics and Development:* A minimum of 13 credits, usually chosen from the following courses: Bio S 385, Developmental Biology; Bio S 389, Embryology; Bio S 480, Seminar in Developmental Biology; Bio S 481, Population Genetics; Bio S 483, Molecular Aspects of Development; Bio S 484, Molecular Evolution; Bio S 485 and 487, Microbial Genetics; Bio S 486, Immunogenetics; Bio S 633 Biosynthesis of Macromolecules; Bio S 639, The Nucleus; Bio S 641, Laboratory in Plant Molecular Biology; Bio S 644, Plant Growth and Development; Bio S 653, Plant Molecular Genetics; Bio S 687, Developmental Genetics; Bio S 688, Yeast Genetics; Bio S 689, Advanced Topics in Population Genetics; An S 419, Animal Cytogenetics.

   Up to 3 credits for this program for study may be chosen from other biological sciences courses with approval of the faculty adviser.

8) *Neurobiology and Behavior:* The two-semester introductory course sequence, Neurobiology and Behavior I and II (Bio S 221 and 222) with discussion section (4 credits per term), and 7 additional credits, among which must be a course from the neurobiology and behavior offerings. Bio S 420, 498, 499, and 720 may not be used as this neurobiology and behavior course. However, these readings and independent research courses may form part of the additional credits (beyond those provided by the advanced neurobiology and behavior course) required to complete the program of study in neurobiology and behavior.

   Note: Students who declare the program of study in neurobiology and behavior after taking Bio S 221 or 222 for only 3 credits must complete additional course work in neurobiology and behavior. These students should consult the chair of the Section of Neurobiology and Behavior (W119 Seeley G. Mudd Hall) to determine what course(s) to use to make up the deficiency.

9) *Independent Option:* Special programs for students interested in biophysics, microbiology (College of Arts and Sciences students only), or nutrition are available under this option. In addition, students who want to undertake a course of study not covered by the eight existing programs of study or one of the special

programs may petition the Division of Biological Sciences Curriculum Committee. Information on independent options and Curriculum Committee petition forms are available in the Office for Academic Affairs, 118 Stimson Hall.

Independent Research and Honors Program

Individual research projects under the direction of a faculty member are encouraged as an aspect of study within a concentration (programs of study). Applicants for research projects are accepted by the individual faculty members, who take into account students' previous academic accomplishments, interests, and goals and the availability of space and equipment suitable for the proposed project. Students accepted for independent research enroll for credit in Biological Sciences 499 (Undergraduate Research in Biology) with the written permission of the faculty supervisor. Students register for this course in 118 Stimson Hall. Any faculty member in the Division of Biological Sciences may act as a supervisor. Faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to take full responsibility for the quality of the work. Information on faculty research activities and undergraduate research opportunities is available in the Behrman Biology Center, G20 Stimson Hall.

Research credits may *not* be used in completion of the following concentration (program of study) areas: animal physiology and anatomy; biochemistry; botany; cell biology; ecology, systematics, and evolution; and genetics and development. No more than 4 credits of research may be used in completion of the concentration area (program of study) in neurobiology and behavior.

The honors program in biological sciences is designed to offer advanced training in laboratory or field research through the performance of an original research project under the direct guidance of a member of the faculty. Applications for the honors program are available in the Office for Academic Affairs, 118 Stimson Hall, and must be submitted to the Honors Program Committee by the deadline announced early in the senior year. Application forms for the honors program are separate from the enrollment forms for Biological Sciences 499 (Undergraduate Research in Biology). To qualify for the program, students must have been accepted into the biological sciences major, have completed at least 30 credits at Cornell, and have an overall Cornell cumulative grade-point average of at least 3.00. In addition, students must have at least a 3.00 Cornell cumulative grade-point average in all biology, chemistry, mathematics, and physics courses. (Grades earned in courses in other departments that are used to fulfill major requirements are included in this computation.) In addition, candidates must have a faculty member to supervise their research. Any faculty member in the Division of Biological Sciences may act as a supervisor. Students may also work with faculty supervisors outside the division. Students who select supervisors outside the division must arrange for a faculty member of the division to serve as cosigner of the research. The division cosigner must agree to meet with the student on a regular basis, to report to the Honors Program Committee on the progress of the work approximately two months before the thesis is due, and to serve as a reviewer of the thesis. An honors candidate usually enrolls for credit in Biological Sciences 499 (Undergraduate Research in Biology) under the direction of the faculty member acting as honors supervisor, although it is not necessary to do so. Students choosing to earn credit for honors research must enroll in Biological Sciences 499 (Undergraduate Research in Biology) separate from the honors program. Requirements of the honors program include participation in honors research seminars during two semesters, submission of an acceptable honors thesis, completion of all major requirements, and maintenance of the 3.00 Cornell cumulative grade-point average through graduation. Recommendation to the faculty that a candidate graduate with honors is the responsibility of the Honors Program Committee.

Students interested in the honors program should consult their faculty advisers early during their junior year. Students are strongly encouraged to begin their research projects in their junior year, although they are not formally admitted to the honors program until the beginning of their senior year. Students who are considering a year abroad should consult with a member of the Honors Committee before beginning their year abroad. Details pertaining to thesis due dates, seminars, and other requirements may be obtained from the chair of the Honors Program Committee or from the Office for Academic Affairs, 118 Stimson Hall. Information on faculty research activities is available in the Behrman Biology Center, G20 Stimson Hall.

CURRICULUM COMMITTEE

Many decisions pertaining to the curriculum, to division-wide requirements, to concentration and breadth requirements, and to the programs of study are made by the Curriculum Committee of the division. The committee consists of faculty and elected student members and welcomes advice and suggestions from all interested persons.

ADVISING

Students in need of academic advice are encouraged to consult their advisers, come to the Behrman Biology Center (G20 Stimson Hall), or contact the associate director for academic affairs (118 Stimson Hall).

Students interested in marine biology should visit the Cornell Marine Programs Office, G14 Stimson Hall.

Students interested in the multidisciplinary program Biology and Society should see "Special Programs and Interdisciplinary Studies," in the College of Arts and Sciences section of this catalog.

INDEX OF COURSES

The middle digits of biological sciences course numbers are used to denote courses in specific areas: 0, general; 1, animal physiology and anatomy; 2 and 9, neurobiology and behavior; 3, biochemistry and cell biology; 4, botany; 6 and 7, ecology, systematics, and evolution; 8, genetics and development. The middle digit 5 is used when all other course numbers in a particular area have already been assigned.

Note: Biological sciences courses count as agriculture and life sciences credits for students in the College of Agriculture and Life Sciences and as arts and sciences credits for students in the College of Arts and Sciences.

Current and Former Course Numbers

GENERAL COURSES

101–102 Biological Sciences, Lectures
101, fall; 102, spring. 2 credits each term. Prerequisite: concurrent enrollment in Biological Sciences 103 (fall) or 104 (spring). Passing grade (D or better) in 101 is prerequisite to 102 unless written permission is obtained from instructor. S-U grades optional, with permission of instructor. May not be taken for credit after Biological Sciences 105–106 or 109–110.

Lecs, M W F 9:05 or 10:10. 2 lecs each week; to accommodate these, students must reserve all 3 days. Evening prelims: fall, Sept. 28 and Nov. 9; spring, Feb. 22 and Apr. 3. K. K. Adler.

Designed both for students who intend to specialize in biological sciences and for those specializing in other subjects, such as the social sciences or humanities, who want to obtain a thorough knowledge of biology as part of their general education. Plant and animal materials are considered together rather than in separate units. The fall semester covers the chemical and cellular basis of life, energy transformations, anatomy, physiology, and behavior. The spring semester covers genetics, development, evolution, ecology, and the origin of life. Each topic is considered in the light of modern evolutionary theory.

103–104 Biological Sciences, Laboratory
103, fall; 104, spring. 2 credits each term. Prerequisite: concurrent enrollment in Biological Sciences 101 (fall) or 102 (spring). 103 is prerequisite to 104 unless written permission is obtained from instructor. S-U grades optional, with permission of instructor. No admittance after second week of classes.

Lab, M T W or R 1:25–4:25, M or W 7:30–10:30 p.m, or T R or S 8–11. One 3-hour lab each week and a weekly lec for discs, special lecs, etc. J. C. Glase, P. R. Ecklund and staff.

Biological Sciences 103–104 is designed to give students laboratory experience with major biological phenomena in order to support an understanding of the important concepts, principles, and theories of modern biology. A second objective of the laboratory course is to help students gain expertise in the methods used by biologists to construct new knowledge. Students are exposed to basic concepts, research methods, including laboratory and data transformation techniques, and instrumentation in the major areas of biology. First-semester topics include biochemistry, physiology, plant biology, and behavior. In the second semester laboratory experience is provided in the areas of genetics, development, organismal diversity, population genetics and growth, and ecology. During the first semester, dissection of a doubly-pithed frog is included. Pithing is done by the instructor.

105–106 Introductory Biology
105, fall; 106, spring. 4 credits each term (or 2 credits, with permission of instructor). Enrollment limited to 200 students. Prerequisite: 105 is prerequisite to 106, unless written permission is obtained from instructor. S-U grades optional, with written permission of instructor. May not be taken for credit after Biological Sciences 101–104 or 109–110. No admittance after first week of classes. Fee, $5.

Lec, T 9:05 (1st lec of fall term, R 8/31 9:05); additional study and lab hours to be arranged. C. H. McFadden and staff.

Designed primarily for biology majors, preprofessionals, and other students who desire a challenging, broad introduction to fundamental concepts of biology. Physiology, anatomy (accompanied by preserved vertebrate dissection), and biochemistry are strongly emphasized in the fall semester. Subjects of study in the spring semester are genetics, development, ecology, evolution, behavior, and the diversity of organisms. The course uses an autotutorial format and offers considerable flexibility in scheduling. Completion of the course requires mastery of a group of core units. Testing on these units is primarily by oral examination. Four formal laboratory sessions are offered each semester. Written reports on experimental work are required in the fall; extensive dissections (both invertebrate and vertebrate) with practical exams constitute spring laboratories. The core units include additional laboratory work. Performance on the core units, the laboratories, and the final examination determine the final grade. Students who object to dissecting live invertebrates may want to take another biology course.

107–108 General Biology
8-week summer session (107, weeks 1–4; 108, weeks 5–8). 4 credits each. Prerequisite: Biological Sciences 101–103, 105, or 107 is a prerequisite for 108. Fee, $35.

Lecs, M-R 9–12; labs, M T & R 1:30–4:30, F 9–12. A. W. Blackler and staff.

Designed for students who plan further study in biology and for students who want a broad course in biology as part of their general education. Topics covered in Biological Sciences 107 include physiology, biology, and metabolism. The laboratory work involves an introduction to some major techniques, vertebrate dissection, and a survey of plant organization. Topics covered in Biological Sciences 108 include genetics, developmental biology, the biology of populations, and evolution. The laboratory work is a continuation of the material covered in Biological Sciences 107 and involves more techniques, a survey of animal organization, and the design and performance of a field study. Biological Sciences 107–108 fulfills the introductory biology requirement for majors and forms a suitable introductory biology course sequence for students intending to go to medical school.

109–110 Biological Principles
109, fall; 110, spring. 3 credits each term. Limited to 600 students. Prerequisite: 109 is prerequisite to 110 unless written permission is obtained from the instructor and student has at least 3 credits of college biology. Letter grades only. May not be taken for credit after Biological Sciences 101–104 or 105–106. This course may be used to fulfill the distribution requirement in the Colleges of Agriculture and Life Sciences, Arts and Sciences, and Human Ecology but may *not* be used as an introductory course for the major in biological sciences. *Note that this course may not always satisfy the prerequisite for second- and third-level courses in biology.*

Lecs, M W F 9:05 or 10:10; lab, M T W R or F 2–4:25 or T 10:10–12:35. Students do not choose lab sections during course enrollment; lab assignments are made during first day of classes. Each student must attend lab on alternate weeks. Evening prelims: fall, Sept. 28 and Nov. 9; spring, Feb. 22 and Apr. 3. R. Turgeon, C. Eberhard.

Students who do not plan to major in biology may take this broad introductory course in modern biology. It is not a course in social biology but addresses itself to biological principles with academic rigor. The content is designed to appeal to anyone who seeks a comprehensive knowledge of biology as part of a general education. Laboratory sections enable small groups of students to meet with the course staff and are used for problem-solving experiments, demonstrations, and discussions. No live dissections are involved; there are dissections of preserved material.

152 Special Topics in Biology
Spring. 1 credit. Limited to 30 students. Prerequisites: superior performance in Biological Sciences 109 or equivalent and concurrent enrollment in Biological Sciences 102, 106, or 110, or written permission of instructor. S-U grades only. *This course may not be used in fulfillment of college distribution requirements.*

Lec, M 3:35: occasional field trips to be arranged. R. Turgeon, C. Eberhard, and guest lecturers.

A lecture course designed to complement introductory biology by providing an opportunity for deeper exploration of selected topics of interest. Class involvement and discussion are encouraged.

200 Special Studies in Biology
Fall or spring. 1–3 credits. Prerequisites: transfer or special-student status and written permission of instructor and of the associate director of the Division of Biological Sciences. Students must register using a special form available in Stimson 118. S-U grades optional, with permission of instructor.

Hours to be arranged. Staff.

A registration device for students who want to take only a portion of a regular biological sciences course—for example, only the lectures or only the laboratory in a course that includes both. Only students who have already had training equivalent to the portion of the regular course that is to be omitted may register in this manner. May not be substituted for 100–level courses and may not be used in fulfillment of college distribution requirements.

202 History of Biology (also Biology and Society 288 and History 288)
Spring. 3 credits. Prerequisite: one year of introductory biology. S-U grades optional.

Lecs, T R 10:10–11:25. W. B. Provine.

An examination of the history of biology, emphasizing the interaction of biology and culture. Original writings of biologists constitute the bulk of reading assignments. Covers the period from classical antiquity to the present, but primary emphasis is on twentieth-century biology.

205 Ethics and Healthcare (also Philosophy 245 and Biology and Society 205)
Fall and summer. 4 credits. Limited to 80 students (25 under Biological Sciences 205, 25 under Biology and Society 205, and 30 under Philosophy 245). Registered students not attending during the first week will be dropped from the course. Open to sophomores, juniors, and seniors; permission of instructor required for graduate students.

Lecs, T R 10: 10–11:25; disc, 1 hour each week to be arranged. M. Wachsberg.

Critical *philosophical* analysis of the conceptual frameworks in which ethical problems associated with healthcare can be formulated and solutions evaluated. General topics (with sample issues in parentheses) include knowledge in ethics (ethical skepticism, ethical relativism); proper social allocation of resources for, and within, medicine (entitlement to health care, access to scarce medical resources, cost-benefit analysis); the proper account of basic concepts such as illness, death, autonomy, and personhood (abortion, euthanasia, procreative technologies); and the professional-patient relationship (informed consent, confidentiality, medical paternalism).

206 Ethics and the Environment (also Philosophy 246 and Biology and Society 206)
Spring. 4 credits. Open to all undergraduates. Permission of instructor required for graduate students.

Lecs, T R 10:10–11:25; disc, 1 hour each week to be arranged. M. Wachsberg.

Critical *philosophical* analysis of the conceptual frameworks in which policies affecting the environment are formulated and judged. An introductory section of the course discusses the nature of ethics and the possibility of knowledge in ethics. The first major substantive component of the course deals with the nature and extent of individual and social obligations to spatially distant people, future generations, nonhuman animals and nonsentient things (e.g., the ecosystem). The second major component of the course deals with the appropriate analysis of the origin of environmental problems and the range of options for their solution. Topics include individual vs. collective goods, cost-benefit analysis, and coordination problems.

207 Evolution (also History 287)
Fall. 3 credits. Intended for students with no background in college biology. May not be taken for credit after Biological Sciences 378. S-U grades optional.

Lecs, T R 10:10; disc, to be arranged. W. B. Provine.

Evolution is the central concept in biology. This course examines evolution in historical and cultural contexts. Aims of the course include understanding the major issues in the history and current status of evolutionary biology and exploring the implications of evolution for culture. Issues range from controversies over mechanisms of evolution in natural populations to the conflict between creationists and evolutionists.

[301 Biology and Society: The Biocultural Perspective (also Anthropology 301 and Biology and Society 301)
Fall. 3 or 4 credits (4 credits by arrangement with instructor; 4–credit option required of Biology and Society majors). Prerequisite: one year of introductory biology. S-U grades optional. This is the core course for the Biology and Society major and is also open to other students who have fulfilled the prerequisite. Not offered 1989–90.

Lecs, T R 11:40–12:55. Staff.

Human biology, behavior, and institutions are understood in modern evolutionary theory as the ongoing products of interactions between human biological evolution and cultural change. Nevertheless, numerous attempts to examine evolutionary processes in humans violate key tenets of evolutionary theory, unwittingly reproducing elements of pre-Darwinian views of human nature. After reviewing the pre-Darwinian context and reading *The Origin of Species,* the course explores attempted applications of evolutionary analysis to humans and develops a cultural explanation of the persistence of pre-Darwinian elements in many of them.]

305 Basic Immunology, Lectures (also Veterinary Medicine 315)
Fall. 3 credits. Strongly recommended: basic courses in microbiology, biochemistry, and genetics.

Lecs, T R 8:30–9:55. Evening prelims: Oct. 12 and Nov. 9. A. J. Winter.

A survey of modern immunology, with emphasis on the biological functions of the immune response.

307 Basic Immunology, Laboratory (also Veterinary Medicine 316)
Fall. 2 credits. Prerequisite: a course in basic microbiology or permission of instructor. Recommended: concurrent enrollment in Biological Sciences 305.

Labs, T R 10:10–1:10. N. L. Norcross.

A series of laboratory exercises selected to illustrate immunological concepts presented in Biological Sciences 305. Exercises are designed to give students experience with the stimulation and measurement of an immune response in the rabbit. Techniques to familiarize students with both humoral and cellular immune phenomena are included, with the goal of offering hands-on experience in immunology. Among the methods and techniques offered are agglutination and precipitation methods, virus neutralization and phagocytosis, measurement of the biological activity of complement components, antibody-dependent cell-mediated cytotoxicity, T and B cell identification, monoclonal antibodies and the ELISA, antibody production by single cells, lymphocyte blastogenesis, and delayed hypersensitivity.

308 Pathogenic Microbiology (also Veterinary Medicine 317)
Spring. 2 or 4 credits (2 credits with lecture only). Limited to 20 students. Prerequisites: Microbiology 290 and 291. Recommended: Biological Sciences 307.

Lecs, T R 1:25; labs, T R 2:30–5. Evening prelim to be arranged. L. E. Winter and staff.

A course in medical microbiology. Lectures discuss the bacteria, fungi, and viruses that cause disease in humans. Emphasis is on the pathogenic mechanisms of the microbes and the interrelationships that exist between the host and the microbe. Laboratory sessions are involved with the isolation, culture, and identification of the microbes and the further study and demonstration of the disease process through use of laboratory animal models and tissue cultures. Dissection of small vertebrate animals (mice) is performed in several of the bacteriology laboratories.

400 Undergraduate Seminar in Biology
Fall or spring. Variable credit (1–3 credits assigned for individual seminar offerings). May be repeated for credit. S-U grades optional.

Sem to be arranged. Staff.

From time to time specialized seminars on topics of interest to undergraduates are offered by visiting faculty or faculty from the Sections of Ecology and Systematics, Genetics and Development, or Plant Biology. Topics and instructors are listed in the division's catalog supplement issued at the beginning of the semester.

401 Introduction to Scanning Electron Microscopy (formerly Biological Sciences 600)
Fall or spring, weeks 1–6. 1 credit. Limited to 8 students (fall), 12 students (spring). Prerequisite: permission of instructor. S-U grades only.

Lec and lab to be arranged. M. V. Parthasarathy.

A general introduction to the principles and the proper use of the scanning electron microscope. Emphasis is on biological material.

403 Transmission Electron Microscopy for Biologists (formerly Biological Sciences 603)
Fall. 1 or 2 credits. 2 credits if student takes both sections. Limited to 12 students. Prerequisites: Biological Sciences 313, 345, 443, or written permission of instructor. S-U grades optional.
Lec, T 11:15; labs, M W or T R 1:25–4:25. Two sections: Sec 01, weeks 1–4; sec 02, weeks 5–8. Students may register for one or both sections. M. V. Parthasarathy.
Section 01, weeks 1–4, covers the principles and techniques of preparing biological material for transmission electron microscopy. Using plant, animal, and microbe materials this section studies chemical fixations, ultrathin sectioning, negative staining, and metal shadowing techniques. Section 02, weeks 5–8, covers the principles and use of the transmission electron microscope (TEM), with emphasis on proper operation of the instrument and interpretation of images obtained. Ultrathin sections as well as negatively stained material from samples prepared in Section 01 are used. Students have 2 additional weeks to complete laboratory assignments at the end of each section.

405 Electron Microscopy in Molecular Biology
Fall, weeks 9–12. 1 credit. Limited to 12 students. Prerequisites: Biological Sciences 403 or proficiency in transmission electron microscopy and written permission of instructor. S-U grades optional.
Lec, T 11:15; labs, M W or T R 1:25–4:25. M. V. Parthasarathy and M. Kyle.
An introductory course to electron microscopy (EM) for use as a tool in analyzing molecular structure, interactions, and processes. Methods considered to be most generally applicable to current studies in molecular biology are covered, including visualization of nucleic acids, heteroduplexes, protein molecules and filaments, and EM immunolabelling.

469 Food, Agriculture, and Society (also Biology and Society 469)
Spring. 3 credits. Prerequisite: an introductory ecology course or permission of instructor. S-U grades optional. Possible fee for course reading materials.
Lecs, T R 1:25–2:40. A. G. Power.
A multidisciplinary course dealing with the social and environmental impact of food production in the United States and in developing countries. Agroecosystems of various kinds are analyzed from biological, economic, and social perspectives. The impacts of traditional, conventional, and alternative agricultural technologies are critically examined in the context of developed and developing economies. Specific topics include pest management, soil conservation, farm labor, land reform, biotechnology, and international food policy.

498 Teaching Experience
Fall or spring. 1–4 credits. Enrollment limited. Prerequisites: previous enrollment in the course to be taught or equivalent, and written permission of instructor. S-U grades optional, with permission of instructor. *Students in the College of Arts and Sciences may not count credits from this course toward the 120 credits required for graduation.*
Hours to be arranged. Staff.
Designed to give qualified undergraduate students teaching experience through actual involvement in planning and assisting in biology courses. This experience may include supervised participation in a discussion group, assisting in a biology laboratory, assisting in field biology, or tutoring. Biological sciences courses currently offering such experience include Biological Sciences 105–106, 231, 274, 311, 319, 330, 430, and 475.

499 Undergraduate Research in Biology
Fall or spring. Variable credit. *Students in the College of Arts and Sciences may not register for more than 6 credits per term with one supervisor or 8 credits per term with more than one supervisor.* Prerequisite: written permission of staff member who supervises the work and assigns the grade. Students must register in the Office for Academic Affairs in Stimson 118. Each student must submit an independent study statement describing the proposed research project during course registration. (Special forms for this purpose are available in the college offices.) S-U grades optional. Any faculty member in the Division of Biological Sciences may act as a supervisor. Faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to serve as cosigner, taking full responsibility for the quality of the work.
Hours to be arranged. Staff.
Practice in planning, conducting, and reporting independent laboratory and library research programs. Research credits may *not* be used in completion of the following concentration areas (programs of study): animal physiology and anatomy; biochemistry; botany; cell biology; ecology, systematics, and evolution; and genetics and development. No more than 4 credits of research may be used in completion of the concentration area (program of study) in neurobiology and behavior.

606 Freeze-Fracture Technique
Spring, weeks 7–12. 1 credit. Primarily for graduate students. Limited to 8 students. Prerequisites: Biological Sciences 403 or equivalent, and permission of instructor. S-U grades only.
Lec, T 11:15; disc to be arranged; labs, T R 1:25–4:25. M. V. Parthasarathy.
Principles of freeze-fracturing and freeze-substitution technique, freezing artifacts, and interpretation of images.

608 Advanced Electron Microscopy for Biologists
Spring, weeks 10–14. 1 credit. Primarily for graduate students. Limited to 6 students. Prerequisite: Biological Sciences 403 or equivalent. S-U grades only.
Hours to be arranged. M. V. Parthasarathy.
Project in biological ultrastructure.

702 X-Ray Elemental Analysis in Biology
Spring, weeks 7–14. 1 credit. Limited to 6 students. Prerequisites: Biological Sciences 403 or equivalent, and permission of instructor. S-U grades only. Offered alternate years.
Lec and lab to be arranged. M. V. Parthasarathy, C. Daugherty.
Principles of X-ray elemental analysis are discussed, with special reference to the energy-dispersive system. Emphasis is on qualitative elemental analysis of biological specimens and preparation of material for such analysis, including freeze-substitution technique. A brief introduction to quantitative elemental analysis is also given.

Related Courses in Other Departments

Medicine and Civilization (Biology and Society 322)

ANIMAL PHYSIOLOGY AND ANATOMY

[214 Biological Basis of Sex Differences (also Women's Studies 214)
Fall. 3 credits. Prerequisite: one year of introductory biology. Limited to non-biology majors and freshman and sophomore biology majors. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lecs, T R 8:30–9:55; occasional disc to be arranged. J. E. Fortune.
The structural and functional differences between the sexes are examined. Emphasis is placed on mechanisms of mammalian reproduction; where possible, special attention is given to studies of humans. Current evidence on the effects of gender on nonreproductive aspects of life (behavior, mental and physical capabilities) is discussed. The course is intended to provide students with a basic knowledge of reproductive endocrinology and with a basis for objective evaluation of sex differences in relation to contemporary life.]

311 Introductory Animal Physiology, Lectures (also Veterinary Medicine 346)
Fall. 3 or 4 credits (4 credits with discussion section). 4–credit option required of students studying animal physiology and anatomy. Prerequisites: one year of college biology, chemistry, and mathematics. S-U grades optional with permission of instructor.
Lecs, M W F 11:15; disc to be arranged. Evening prelims: Sept. 21 and Nov. 2. E. R. Loew and staff.
A general course in animal physiology emphasizing principles of operation, regulation, and integration common to a broad range of living systems from the cellular to the organismal level. Structure/function relationships are stressed along with underlying physico-chemical mechanisms.

313 Histology: The Biology of the Tissues
Fall. 4 credits. Prerequisite: one year of introductory biology. Recommended: background in vertebrate anatomy and organic chemistry or biochemistry.
Lecs, T R 11:15; labs, T R 2–4:25. R. B. Silver.
Provides students with a basis for understanding the microscopic, fine-structural, and functional organization of vertebrates, as well as methods of analytic morphology at the cell

and tissue levels. Dynamic interrelations of structure, composition, and function in cells and tissues are emphasized. The course may include work with invertebrate or vertebrate animals.

316 Cellular Physiology
Spring. 4 credits. Limited to 100 students, with preference given to students studying in animal physiology and anatomy. Each lab limited to 24 students. Prerequisite: concurrent or previous enrollment in Biological Sciences 330 or 331.
Lecs, M W F 9:05; lab, M T W or R 1:25–5. A. Quaroni and staff.
Lectures introduce students to the most current information on the ways cells function and regulate themselves and neighboring cells and on what molecules are involved in these regulatory processes. Laboratories provide an introduction to cell and organ culture and to immunological techniques used to study cell structure and function *in vivo* and *in vitro*. Experiments performed in the laboratory are closely related to, and provide practical experience with, subjects covered in the lectures. Vertebrate animals are used in this course. No experimentation is performed on live animals.

319 Animal Physiology Experimentation (also Veterinary Medicine 348)
Fall. 3 credits. Enrollment limited to 80 students, with preference given to students studying in animal physiology and anatomy. Each of 4 afternoon laboratory sections limited to 20 students. Prerequisite: concurrent or previous enrollment in Biological Sciences 311 or permission of instructor based on previous meritorious performance in another introductory animal physiology course.
Lab, M T W or R 1:25–5; disc, R 1:25, F 12:20 or 1:25. Student do not choose disc sections during course enrollment; disc assignments are made during first day of classes. R. A. Corradino, P. W. Concannon.
A series of student-conducted *in vitro* and *in vivo* experimental exercises designed to illustrate basic physiological processes in animals and to introduce students to animal physiology research techniques, instrumentation, experimental design, and interpretation of results. Protocols include anesthesia, dissection, vivisection, physiographic recording, and computer simulations. Experiments with living tissues and live animals examine properties of blood, muscle, and nerves; cardiovascular, respiratory and gastrointestinal function and control; and endocrine regulation of mineral metabolism and reproductive tissue activity. Experimental resources include live animals of several vertebrate species, including frogs, birds, rats, and rabbits, which are sacrificed in conjunction with the laboratory exercises. Written reports of laboratory activities are required. Grading is based on evaluation of these reports and on laboratory performance.

410 Seminar in Anatomy and Physiology
Fall or spring. 1 credit. May be repeated for credit only once. Limited to upperclass students. S-U grades only.
Sem to be arranged. Organizational meeting first W of each semester at 7:30 p.m. in Stimson 105. Staff (coordinator, D. Robertshaw).
Discussions and seminars on specialized topics in animal physiology and anatomy.

458 Mammalian Physiology
Spring. 3 credits. Enrollment limited. Graduate student auditors allowed in lectures. Prerequisite: Biological Sciences 311 or equivalent with permission of instructor.
Lecs, M W F 10:10. K. W. Beyenbach and staff.
An in-depth treatment of selected topics in mammalian physiology and human physiology. Emphasis is on a conceptual and working knowledge of physiology rather than a factual, memorizing knowledge. Topics selected, in order of presentation, include recurrent themes in physiology; basic functional elements of biological systems; design of multicellular animals; mammalian fluid compartments; homeostasis; cardiovascular, respiratory, gastro-intestinal, and renal physiology; and energy metabolism. The course concludes with a discussion of integrative physiology by considering the multiple, parallel short-term responses of the human body to exercise. Recommended for biological sciences majors, pre-med and pre-vet students, and beginning graduate students in physiology, nutrition, and animal science.

[615 Nutrition and Physiology of Mineral Elements (also Veterinary Medicine 759 and Nutritional Sciences 659)
Fall. 2 credits. Prerequisites: courses in basic physiology, intermediate biochemistry, and general nutrition. Offered alternate years. Not offered 1989–90.
Lecs, T R 10:10. R. H. Wasserman, R. Schwartz, D. R. Van Campen.
Lectures on nutritional aspects and physiological, biochemical, and hormonal relationships of the prominent macroelements and microelements, with emphasis on recent developments. Information on methodologies of mineral research and the requirements for and essentiality, transport, function, homeostasis, interrelationships, and toxicity of various mineral elements.]

[618 Biological Membranes and Nutrient Transfer (also Veterinary Medicine 752)
Spring. 2 credits. Prerequisites: courses in animal or plant physiology, quantitative and organic chemistry, and physics. Recommended: a course in cellular physiology. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs, T R 11:15. R. H. Wasserman.
An introduction to elementary biophysical properties of biological membranes; theoretical aspects of permeability and transport; mechanism of transfer of inorganic and organic substances primarily across epithelial membranes; and characteristics and properties of transporting macromolecules and ion channels.]

619 Lipids (also Nutritional Sciences 602)
Fall. 2 credits.
Lecs, T R 11:15. A. Bensadoun.
Advanced course on biochemical, metabolic, and nutritional aspects of lipids. Emphasis is placed on critical analysis of current topics in lipid methodology; lipid absorption; lipoprotein secretion, molecular structure, and catabolism; mechanism of hormonal regulation of lipolysis and fatty acid synthesis; and cholesterol metabolism and atherosclerosis.

658 Molecular Mechanisms of Hormone Action (also Veterinary Medicine 758)
Spring. 2 credits. Prerequisite: permission of instructor. Minimum enrollment of 6 required. Offered alternate years.
Lecs, T R 10:10. R. A. Corradino.
An advanced course developed from the current literature on endocrine mechanisms.

710–718 Special Topics in Physiology
Fall or spring. 1 or 2 credits for each topic. May be repeated for credit. Enrollment in each topic may be limited. S-U grades optional, with permission of instructor. Lectures, laboratories, discussions, and seminars on specialized topics.
Fall 1989: one topic is offered.

717 Structure and Function of Joints with Emphasis on Arthritis
1 credit.
Lec, 1 hour each week to be arranged. G. Lust.
Spring 1990: two topics are offered.

712 Plasma Lipoproteins
1 credit.
Sem, hour each week to be arranged. A. Bensadoun.

714 Physiology of Pregnancy
2 credits.
Lab to be arranged. P. W. Nathanielsz.

719 Graduate Research in Animal Physiology (also Veterinary Medicine 600)
Fall or spring. Variable credit. Prerequisites: written permission of the section chair and of the staff member who supervises the work and assigns the grade. Students must register in Vet Research Tower 725. S-U grades optional.
Hours to be arranged. Staff.
Similar to Biological Sciences 499 but intended for graduate students who are working with faculty members on an individual basis.

753 Animal Biotechnology
Fall. 3 credits. Prerequisites: two courses in physiology, two courses in biochemistry, and one course in endocrinology or nutrition.
Lec and disc, M 11:15; lab, M 1:25–4:20; additional hours to be arranged. W. Hansel and staff.
A course in animal biotechnology designed to prepare students for research in animal genetic engineering. Standard techniques for cloning DNA in bacteria are discussed. Development of expression systems in bacteria, yeast, and mammalian cells; DNA sequencing and analysis; and insertion of DNA into mammalian cells are carried out in the laboratory.

Related Courses in Other Departments

Adaptations of Marine Organisms (Biological Sciences 413)

Advanced Work in Animal Parasitology (Veterinary Medicine 737)

Animal Development (Veterinary Medicine 507)

Animal Reproduction and Development (Animal Science 220)

Developmental Biology (Biological Sciences 385)

Embryology (Biological Sciences 389)

Fundamentals of Endocrinology (Animal Science 427–428)

Insect Morphology (Entomology 322)

Integration and Coordination of Energy Metabolism (Biological Sciences 637 and Nutritional Sciences 636)

Neuroanatomy (Veterinary Medicine 504)

Sensory Function (Biological Sciences 492)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

BIOCHEMISTRY, MOLECULAR AND CELL BIOLOGY

132 Orientation Lectures in Biochemistry
Spring, weeks 1–3. No credit. Primarily for freshmen, sophomores, and transfer students. S-U grades only (registered students receive an unsatisfactory grade for nonattendance).
Lec, S 10:10–11:00, for first 3 S of semester. Section chair and staff.
Discussions by six professors about their research and promising areas for research in the future.

231 General Biochemistry
Fall. 3 credits. Intended for students who have not studied biochemistry previously and who do not expect to pursue it further. Not recommended for students who have taken organic chemistry. Prerequisite: Chemistry 104 or 208 or equivalent. S-U grades optional.
Lecs, M W F 12:20. J. M. Griffiths.
A brief introductory section relating organic chemistry to biochemistry is given, followed by the biochemical material in the usual one-semester introductory courses. Topics of general interest are also included.

232 Recombinant DNA Technology and Its Applications (also Biology and Society 232)
Spring. 3 credits. Prerequisite: one year of introductory biology. S-U grades optional.
Lecs, M W F 11:15. F. H. Buttel, J. M. Calvo, J. M. Fessenden MacDonald, and staff.
An introduction to molecular approaches to biology. Basic concepts underlying recombinant DNA technology together with strategies for cloning genes are discussed. Much of the course deals with applications of recombinant DNA technology to basic research and to biotechnology. Applications to be discussed include screening for genetic diseases, animal and plant improvement, and production of proteins useful in medicine, agriculture, and industry. Historical, regulatory, social, and ethical issues are presented and discussed. Recommended especially for freshman with AP biology credit and sophomores desiring a firm background in recombinant DNA technology in preparation for taking genetics and biochemistry. Also appropriate for nonmajors.

330–331 Principles of Biochemistry
Introductory biochemistry is offered in two formats: individualized instruction (330) and lectures (331). *Individualized instruction is offered to a maximum of approximately 150 students each semester. Lectures given fall semester only.*

330 Principles of Biochemistry, Individualized Instruction
Fall or spring. 4 credits (2 credits if taken after Biological Sciences 231). Prerequisite: Chemistry 253 or 358 or equivalent. May not be taken for credit after Biological Sciences 331. S-U grades optional for graduate students only.
Evening prelims: fall, Oct. 26; spring, Mar. 13. Fall: M. Ferger and staff; spring: M. Ferger, R. Wu, and staff.
The core material of the course includes protein structure and function, enzymes, basic metabolic pathways, DNA, RNA, protein synthesis, and an introduction to gene cloning. There are no formal lectures; the course has an autotutorial format. The core material is divided into twelve units of work that are outlined in a study guide written to accompany the textbook. Students prepare the work on their own, with help from the staff of the Study Center if desired.

Students must pass a quiz on each unit to obtain a grade of C+. Grades above C+ (to a maximum of B+) are determined by the amount of elective work satisfactorily completed by participation in optional discussion groups. Grades above B+ are earned by high grades on the midterm and final exams. The optional discussion groups are scheduled M W F 8 and 10:10 and at other hours. A student attends once a week at one of those times, for a maximum of 8 weeks during the semester. Missed deadlines or very poor exam scores result in grade penalties.

331 Principles of Biochemistry, Lectures
Fall or 6–week summer session. 4 credits (or 2 credits if taken after Biological Sciences 231). Enrollment may be limited to 400 students in fall. Prerequisite: Chemistry 253 or 358 or equivalent. May not be taken for credit after Biological Sciences 330. S-U grades optional for graduate students only.
Lecs, M W F S 10:10. J. K. Moffat, R. Barker, B.-K.Tye.
Chemistry of biological substances presented in lecture format. Course content is similar to that of Biological Sciences 330.

430 Basic Biochemical Methods
Fall or spring. 4 credits. Enrollment limited. Prerequisites: Biological Sciences 330 or 331, organic chemistry lectures and laboratory, and permission of instructor obtained by preregistering in Stimson 229. Concurrent registration in Biological Sciences 330 or 331 may be arranged in the fall term for graduate students.
Lec and disc, F 1:25; labs, M W or T R 12:20–4:25. R. R. Alexander, J. M. Griffiths, and staff.
A laboratory course designed to introduce students to the biochemical techniques commonly used in the study of biological materials. Students work in small groups, and each student may select two of three or four modules offered. Various assay methods, chromatography, electrophoresis, and use of the scintillation counter are taught. Protein isolation, purification, and enzyme characterization methods are included. Techniques used in the clinical laboratory are applied to analyses of blood and urine samples, and some nutritional analyses are done for protein and vitamin contents of foods. In the nucleic acids module, students are introduced to recombinant DNA methodology, isolating DNA, and studying the function of transfer RNA. A student may isolate and purify the lipids from a material of his/her choice and perform thin-layer chromatography and carry out cholesterol and phosphate analyses. Separation techniques are used to isolate cell components and experiments are conducted to illustrate basic biochemical methods.

432 Survey of Cell Biology
Spring. 3 credits. Prerequisite: Biological Sciences 330 or 331 or equivalent. S-U grades optional for graduate students only.
Lecs, M W F 11:15. W. J . Brown and staff.
A survey of a wide array of topics focusing on the general properties of eucaryotic cells. The topics include methods used for studying cells, the structure and function of the major cellular organelles, and analyses of cellular processes such as mitosis, endocytosis, cell motility, secretion, cell-to-cell communication, gene expression, and oncogenesis. Some of the material is covered in greater depth in Biological Sciences 438, 483, 632, 636, and 639.

435–436 Undergraduate Biochemistry Seminar
435, fall; 436, spring. 1 credit each term. May be repeated for credit. Limited to upperclass students. Prerequisite: Biological Sciences 330 or 331 or written permission of instructor. S-U grades only.
Sem to be arranged. Organizational meeting first W of each semester at 4 p.m. Fall: T. Huffaker; spring: B.-K. Tye.
Selected papers from the literature on a given topic are evaluated critically during six or seven two-hour meetings.

438 Cell Proliferation and Oncogenic Viruses (also Toxicology 438)
Spring. 3 credits. Prerequisite: Biological Sciences 330 or 331. Recommended: Biological Sciences 281.
Lecs, T R 12:20–1:35. V. M. Vogt.
A description of the growth properties of animal cells in culture, followed by discussions of the changes in cells that are induced by tumor viruses and carcinogens. Topics include immortalization of cells, the cell cycle, macromolecular growth factors, cell-surface properties, cell cytoskeleton, transcription and translation of retrovirus genes, and structure and function of viral and cellular *onc* genes.

630 Laboratory in Cell Biology
Spring. 4 credits. Enrollment limited. Prerequisites: a course in biochemistry or cell biology, and permission of instructor obtained by registering in 258 Biotechnology Building with J. Gibson.
Labs, M W 1:25–4:25 or R 9:05–4:25; disc to be arranged. J. Gibson and staff.
The course emphasizes techniques for handling and experimenting with cells of different kinds and provides experience in experimental design. Limited numbers of vertebrate animals are used for two experiments where no alternative approach exists.

631 Protein Structure and Function
Fall. 2 or 3 credits (3 credits with discussion). Prerequisites: introductory biochemistry, physical chemistry, and organic chemistry. Permission of instructor required for discussion. S-U grades optional for lecture; S-U grades only for discussion.
Lecs, M W 9:05; disc, F 9:05. P. A. Karplus.
Lectures on protein structure and the nature of enzymatic catalysis. Discussions cover some of these areas in more depth, through recent research papers.

632 Membranes and Bioenergetics
Spring. 2 credits. Prerequisite: Biological Sciences 330 or 331 or equivalent. Offered alternate years.
Lecs, T R 11:15. P. C. Hinkle, R. E. McCarty.
Structure and dynamics of biological membranes, physical methods, model membranes, ionophores, ion-transport ATPases, mitochondrial and chloroplast electron transfer chains, and examples of transport from plants, animals, and bacteria.

633 Biosynthesis of Macromolecules
Fall. 2 credits. Prerequisite: Biological Sciences 330 or 331. Recommended: Biological Sciences 281.
Lecs, T R 9:05. J. W. Roberts, D. B. Wilson.
Synthesis of DNA, RNA, and proteins, and regulation of gene expression.

634 Biochemistry of the Vitamins and Coenzymes (also Nutritional Sciences 634)
Spring. 2 credits. Prerequisites: Biological Sciences 330 or 331 or equivalent and either Chemistry 358 or 360. Offered alternate years.
Lecs, T R 10:10. M. N. Kazarinoff.
Lectures on the chemistry, biochemistry, and physiology of vitamins and coenzymes. Emphasis is placed on the relationship of structure and function, and mechanisms are examined in detail. Readings from the current primary literature are assigned weekly.

635 Mechanisms of Metabolic Regulation (also Nutritional Sciences 635)
Spring. 2 credits. Prerequisites: Biological Sciences 330 or 331 and either Chemistry 358 or 360, or permission of instructor. Offered alternate years.
Lecs, T R 9:05. Staff.
Lectures on the identification and characterization of regulatory steps in metabolism, considered from both theoretical and practical aspects. The intracellular mechanisms of regulation are emphasized, with specific examples in mammalian metabolism examined in detail.

636 Current Topics in Cell Biology
Spring. 2 credits. Prerequisites: Biological Sciences 330 or 331, and 432, or their equivalents.
Lecs, T R 10:10. A. P. Bretscher.
Lectures covering current topics in cell biology, including a detailed discussion of secretion, endocytosis, membrane-bound organelles, membrane recycling, the cytoskeleton, cell motility, junctions, the cell cycle, and related topics. Together with Biological Sciences 632 and 639, this course provides broad coverage of the cell biology subject area.

637 Integration and Coordination of Energy Metabolism (also Nutritional Sciences 636)
Fall. 3 credits. Prerequisite: Biological Sciences 330 or 331 or equivalent.
Lecs, M W F 9:05. Evening prelims to be arranged. W. J. Arion.
The elements and dynamics of energy metabolism in higher animals are developed systematically through biochemical characterizations of the metabolic components and structure of major tissues and organs. Emphasis is placed on correlations with physiologic functions. Mechanisms that control energy metabolism within individual tissues and coordinate these processes in intact animals are analyzed in the contexts of selected physiologic and pathologic stresses.

638 Intermediate Biochemical Methods
Fall or spring. 4 credits. Primarily for graduate students minoring in biochemistry and undergraduates concentrating in biochemistry. Enrollment limited to 24 students in the fall and 48 students in the spring. Admission to the course is dependent upon the results of a personal interview with the teaching support specialist (x5-2435 or x5-5706), which must be held before the first day of classes. *There is no admission to the course without the interview.* Undergraduates are urged to interview during preregistration. May not be taken for credit after Biological Sciences 430.
Lab, T 9:05–4:25 (fall): lab, T or R 9:05–4:25 (spring). D. B. Wilson and staff.
Selected experiments on proteins, enzymes, DNA, and bioenergetics to illustrate basic biochemical properties. The course emphasizes quantitative aspects and techniques currently used in biochemical research.

639 The Nucleus
Spring. 2 credits. Prerequisite: Biological Sciences 330 or 331 or equivalent. Recommended: Biological Sciences 281.
Lec, M 8–9:55 p.m. J. T. Lis.
Lectures on topics of eucaryotic gene organization, regulation of gene expression, RNA processing, chromatin structure, the structure and movement of chromosomes, and the architecture of the nucleus. This course and Biological Sciences 632 and 636 provide broad coverage of the cell biology subject area.

[648 Plant Biochemistry
Spring. 3 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. Offered alternate years. Not offered 1989–90.
Lecs, M W F 9:05. A. T. Jagendorf, R. E. McCarty, J. F. Thompson.
Selected areas of plant biochemistry are reviewed in the context of the plant life cycle and responses to the environment. Topics include metabolism of lipids, carbohydrates, organic acids, and proteins; nitrogen and sulfur assimilation; respiration; photosynthesis; development and replication of chloroplasts; and cell-wall composition and properties. Attention is paid to operation of control mechanisms.]

[650 Nitrogen Metabolism (also Nutritional Sciences 607)
Spring. 2 credits. Prerequisites: Biological Sciences 330 or 331 and Chemistry 358 or 360. Offered alternate years. Not offered 1989–90.
Lecs, T R 9:05. M. Watford.
A coverage of most aspects of nitrogen metabolism. The first section of the course deals with nitrogen fixation and assimilation, and the metabolism and biological importance of purines, pyrimidines, porphyrins, alkaloids, and amines. This is followed by discussion of the pathways of amino acid biosynthesis and degradation. The final section includes discussion of protein turnover and degradation, nitrogen excretion, and interorgan relationships in higher organisms. Emphasis throughout the course is on hormonal, developmental, and molecular biological aspects of metabolic regulation and evolutionary differences.]

[659 Risk Management of Toxic Chemicals (also Biology and Society 459 and Toxicology 659)
Fall. 2 or 3 credits (3 credits with major research paper). Prerequisite: concurrent enrollment in Toxicology 610 or permission of instructor. Limited to 12 students. S-U grades optional. Offered alternate years. Not offered 1989–90.
Sem, T 2:30–4:25. J. M. Fessenden MacDonald.
Selected cases of chemical risk communication and risk management by government agencies, communities, industries, and individuals are reviewed. Potential topics include toxic wastes, groundwater contamination, chemical accidents and occupational and community right-to-know. The roles of social, economic, political, legal, and ethical factors in decision making are discussed. Readings from the various disciplines, as well as scientific reports, provide background for class discussions.]

731–736 Current Topics in Biochemistry
Fall or spring. 1/2 or 1 credit for each topic. May be repeated for credit. Prerequisite: Biological Sciences 330 or 331 or equivalent. S-U grades only.
Lectures and seminars on specialized topics.
Fall 1989: three topics are offered.

731 Current Topics in Biochemistry
1/2 credit.
T R 12:20 (6 lecs) Sept. 12–28. Staff.

733 Microfilaments and the Regulation of Cell Structure
1/2 credit.
T R 12:20 (6 lecs) Oct. 24–Nov. 9. A. P. Bretscher.

735 Transport ATPase, with Emphasis on Plants
1/2 credit.
T R 12:20 (6 lecs) Nov. 14–Dec. 5. R. E. McCarty.
Spring 1990: three topics are offered.

732 Current Topics in Biochemistry
1/2 credit.
T R 7:30–9:30 p.m. (6 lecs) Jan. 30–Feb. 15. C. Seeger.

734 Current Topics in Biochemistry
1/2 credit.
T R 12:20 (6 lecs) Feb. 20–Mar. 8. Staff.

736 Molecular Membrane of Growth Factor Action
1/2 credit.
T R 12:20 (6 lecs) Apr. 3–19. R. Cerione.

737 Advanced Biotechnology Laboratory
Summer (3–week session). 3 credits. Enrollment limited to 8 students. Prerequisites: Biological Sciences 630, 638, or equivalent laboratory experience and permission of instructor. S-U grades only.
Lecs, M–F 9–5. D. B. Wilson, J. E. Blankenship, and staff.
Experiments are designed to demonstrate advanced recombinant DNA techniques that are currently of interest. Students prepare intact yeast chromosomes and resolve them electrophoretically using field inversion electrophoresis. The DNA in the gel is transferred to nitrocellulose. The chromosomal location of specific genes is determined. Students end label DNA with 32P and perform DNase footprinting experiments. DNA sequences are determined by chemical modification and dideoxy strand termination methods.

751 Professional Responsibilities of Toxicologists (also Toxicology 751)
Fall. 2 credits. Prerequisites: advanced graduate standing and permission of instructor. S-U grades optional. Offered alternate years.
Sem, W 2:30–4:25. J. M. Fessenden MacDonald.
Case studies of professional responsibilities and dilemmas faced by toxicologists in academia, industry, and government, with discussions of possible approaches, alternatives, and outcomes. Readings of scientific, ethical, and general papers provide background for discussions. Topics for consideration include legal liabilities, chemical-safety issues, data presentation and partisanship, communicating with the public, conflicts of interest/commitment, peer review, and professional codes of ethics.

752 Isotope Kinetics (also Nutritional Sciences 682)
Spring. 2 credits. Prerequisite: calculus. S-U grades only. Offered alternate years.
Lec, T 7:30–9:30 p.m. D. B. Zilversmit.
Quantitative analysis of the transport and distribution of nutrients, metabolites, and drugs in multicompartmental systems. The material is presented as lectures, discussion groups, and problem sets.

830 Biochemistry Seminar
Fall or spring. No credit.
Sem, F 4:30. Staff.
Lectures on current research in biochemistry, presented by distinguished visitors and staff members.

831 Advanced Biochemical Methods I
Fall. 6 credits. Limited to graduate students majoring in biochemistry. S-U grades optional.
Labs and discs, 12 hours each week to be arranged. Organizational meeting first R of semester at 10:10. D. B. Wilson and staff.
To learn the basic techniques of biochemical research, each student performs experiments on proteins, enzymes, DNA, and bioenergetics. First half of the fall term is an intensive lab course with defined experiments assigned to the students. Letter grades are assigned for this laboratory portion of the course. Second half of the fall term is devoted to a rotation project in different labs selected by the students. S-U grades only are assigned for the rotation portion of the course.

832 Advanced Biochemical Methods II
Spring. 6 credits. Limited to graduate students majoring in biochemistry. S-U grades only.
Lab to be arranged. Staff (coordinator: graduate field representative).
Research in the laboratories of two or three different professors chosen by the student. Arrangements are made jointly between the graduate field representative and the research adviser.

833 Research Seminar in Biochemistry
Fall and spring. 1 credit each term. (Students must register for 2 credits each term, since an "R" grade is given at the end of the fall term.) May be repeated for credit. Required of, and limited to, second-, third-, and fourth-year graduate students majoring in biochemistry. S-U grades only.
Sem, T 5–6:30 p.m. T. C. Huffaker, W. J. Brown, J. T. Lis.
Each student presents one seminar per year on his or her thesis research and then meets with instructors and thesis committee members for evaluation.

Related Courses in Other Departments

Lipids (Biological Sciences 619 and Nutritional Sciences 602)

Molecular Aspects of Development (Biological Sciences 483)

Molecular Mechanisms of Hormone Action (Biological Sciences 658 and Veterinary Medicine 758)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

BOTANY

241 Introductory Botany
Fall. 4 credits. Enrollment may be limited, with preference given to sophomores and juniors majoring in agronomy, botany, environmental education, floriculture, horticulture, natural resources, plant sciences, vegetable crops, and wildlife. Prerequisite: one year of introductory biology or permission of instructor.
Lecs, M W F 9:05; lab, M T W R or F 1:25–4:25, or M or W 7:30–10:30 p.m. K. J. Niklas.
Introductory botany for those who plan to specialize in or use some aspect of the plant sciences. Emphasizes structure, reproduction, and classification of angiosperms and the history of life on earth. Laboratory emphasizes development of skills in handling plant materials, including identification. First and second weeks of laboratory are field trips, starting with the first day of classes. *Those who register for an evening laboratory are still required to attend the afternoon field trips.*

242 Plant Physiology, Lectures
Spring. 3 credits. Primarily for undergraduates in agricultural sciences. Prerequisites: one year of introductory biology and introductory chemistry. Concurrent enrollment in Biological Sciences 244 required of undergraduates. May not be taken for credit after Biological Sciences 341 except by written permission of instructor.
Lecs, M W F 10:10. C. Reiss.
Plant physiology as applied to plants growing in communities. Examples deal with crop plants or higher plants where possible, though not exclusively. Topics include cell structure and function; plant metabolism, including photosynthesis; light relations in crops; plant-water relations; water uptake, transport, and transpiration; irrigation of crops; sugar transport; mineral nutrition; growth and development—hormones, flowering, fruiting, dormancy, and abscission; stress.

244 Plant Physiology, Laboratory
Spring. 2 credits. Prerequisite: concurrent enrollment in Biological Sciences 242. May not be taken for credit after Biological Sciences 349.
Disc and lab, M T W or R 12:20–4:25. C. Reiss.
Experiments exemplify concepts covered in Biological Sciences 242 and offer experience in a variety of biological and biochemical techniques, including use of small amounts of radioisotopes.

245 Plant Biology
Summer (6-week session). 3 credits. Limited to 24 students.
Lecs, M–F 11:30–12:45; labs, M W 1:30–4:30. S. Williams.
Introductory botany, including plant identification. Emphasizes structure, reproduction, and classification of angiosperms. Seventy-five percent of the laboratory work is conducted outdoors in an area that surpasses most biological stations. Those who lack college-level biology are expected to work more closely with the instructor on supplemental instructional materials.

246 Plants and Civilization
Spring. 3 credits.
Lecs, T R 11:15; disc, T W or R 12:20 or W 1:25. D. M. Bates.
A consideration of the role that plants have played and continue to play in the evolution of human cultures. Emphasis is on the interactions between humans and the plant environment, the nature of plants and manner in which humans use and integrate them into their cultures, and the problems and concerns related to contemporary and future use of plant resources.

248 Taxonomy of Vascular Plants
Spring. 4 credits. Prerequisite: one year of introductory biology. May not be taken for credit after Biological Sciences 342.
Lecs, M W F 9:05; labs, W or R 1:25–4:25. J. I. Davis.
An introduction to the classification of vascular plants, with attention to the goals of taxonomy, the processes of plant evolution, and the means of analyzing evolutionary relationships among plants. The laboratory concentrates on methods of plant identification and an overview of vascular plant diversity, with particular attention to the flowering plants.

341 Plant Physiology, Lectures
Fall. 3 credits. Prerequisites: one year of introductory biology, organic chemistry, and either concurrent enrollment in Biological Sciences 349 or written permission of instructor. May not be taken for credit after Biological Sciences 242 unless written permission is obtained from instructor.
Lecs, T R 10:10–11:25. D. M. Law.
The behavior, growth, transport processes, and environmental response of plants. Topics include membrane properties, solute and water transport, and function of osmotic forces; mineral and organic nutrition; stress resistance; growth and development controls; metabolism, including photosynthesis and respiration; and responses to environmental influences.

[342 Taxonomy of Cultivated Plants (also Floriculture and Ornamental Horticulture 342)
Spring. 4 credits. Prerequisite: one year of introductory biology or written permission of instructor. May not be taken for credit after Biological Sciences 248. Not offered 1989–90.
Lecs, M W 10:10; labs, M W 2–4:25. Bailey Hortorium staff.
A study of ferns and seed plants, their relationships, and their classification into families and genera, emphasizing cultivated plants. Particular emphasis is placed on gaining proficiency in identifying and distinguishing families and in preparing and using analytic keys. Attention is also given to the economic importance of taxa, to the basic taxonomic literature, and to the elements of nomenclature.]

345 Plant Anatomy
Fall. 4 credits. Limited to 25 students. Prerequisite: one year of introductory biology or a semester of botany.
Lecs, M W 9:05; labs, M W 2–4:25. D. J. Paolillo.
A descriptive course with equal emphasis on development and mature structure. Lecture, laboratory, and reading are integrated in a study guide. The laboratory offers the opportunity to develop the practical skills required to make anatomical diagnoses and to write anatomical descriptions.

346 Algal Physiology
Fall. 3 credits. Prerequisites: one year of introductory biology for majors and Biological Sciences 242 or 341, or permission of instructor. S-U grades optional. Offered alternate years.
Lecs, T R 8:30–9:55. T. G. Owens.
A brief description of the algal classes, as well as classical and emerging criteria for taxonomic classification. Discussions include the interactions of algae with their physical and chemical environments, uptake of inorganic compounds, algal photosynthesis, and metabolic strategies of unicellular and macrophytic algae. Emphasis is placed upon physiological comparisons between algae and higher plants.

349 Plant Physiology, Laboratory
Fall. 2 credits. Prerequisite: concurrent enrollment in Biological Sciences 341. May not be taken for credit after Biological Sciences 244.
Lab, W or R 1:25–4:25; disc, W or R 12:20. Lab and disc must be on same day. C. Reiss.
Experiments exemplify concepts covered in Biological Sciences 341 and offer experience in a variety of biological and biochemical techniques, including use of small amounts of radioisotopes.

[359 Biology of Grasses
Fall. 3 credits. Limited to 24 students. Prerequisite: one year of introductory biology or an introductory plant taxonomy course, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lecs, T R 10:10; lab,T 1:25–4:25. J. I. Davis.
Systematics and ecology of the graminoid plant families (grasses, sedges, and rushes), with principal emphasis on grasses. Major topics include taxonomy, phylogenetics, physiology, reproductive biology, ecotypic variation, speciation, biogeography, and population biology. The role of graminoids as ecosystem dominants, weeds, and the origins of cultivated species are discussed. Laboratory concentrates on the diversity of grasses.]

[440 Plant Geography
Spring. 2 credits. Prerequisite: Biological Sciences 248 or equivalent. Recommended: Biological Sciences 378 or 463 or both. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs, T R 10:10. Bailey Hortorium staff.
Patterns of distribution and variation of plant species and higher taxa, endemism and disjunction and their causes, influences of past continental movements and climatic change on plant distributions, geographical aspects of plant speciation, major biomes and floristic regions of the world, and methods of phytogeographic analysis.]

[441 Crop Plant Evolution
Fall. 2 credits. Prerequisite: an advanced-level course in the plant sciences with taxonomic content or permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs, T R 11:15. D. M. Bates.
An integrated study of the systematics and evolution of agronomic and horticultural species. Processes of domestication, the evolutionary history of selected cultigens, the nature of weeds and land races, classification and nomenclature as applied to cultivated plants, and underexploited plant resources are among the topics considered.]

[442 Biology of Plant Species
Spring. 2 credits. Prerequisite: Biological Sciences 248 or equivalent. Recommended: Biological Sciences 378 and 463. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs, T R 10:10. Bailey Hortorium staff.
A comprehensive introduction to the nature and origin of plant species, with coverage of plant evolutionary genetics, race formation and modes of speciation, evolution of reproductive isolating mechanisms, types of species complexes found in plants, cytogenetic aspects of plant speciation, natural hybridization and its consequences, and the origin and nature of higher taxa.]

[443 Research Methods in Systematic Botany
Fall. 2 credits. Limited to 10 students. Prerequisite: Biological Sciences 248 or equivalent. Offered alternate years. Not offered 1989–90.
Lab, F 1:25–4:25; additional hours to be arranged. Bailey Hortorium staff.
An introduction to the methodology of plant systematic research: field studies; sampling and collecting methods; preparation of taxonomic revisions and monographs; numerical methods of data analysis; and laboratory methods in cytogenetics, comparative anatomy, and comparative chemistry, as applied to problems in plant systematics.]

444 Plant Cell Biology
Fall. 4 credits. Limited to 24 students. Prerequisites: Biological Sciences 242 or 341, and 345, or permission of instructor.
Lecs, M W F 11:15; lab, M or W 1:25–4:25. R. O. Wayne.
Evidence from microscopy, physiology, biochemistry, and molecular biology is used to try to unravel the mystery of the living cell. The dynamics of protoplasm, membranes, and the various organelles are studied. The mechanisms of cell growth and division, the relationship of the cytoskeleton to cell shape and motility, the interaction of the cell with its environment, and the processes that give rise to multicellular differentiated plants are investigated.

[445 Photosynthesis (also Applied and Engineering Physics 601)
Fall. 3 credits. Prerequisites: Chemistry 104 or 208, Mathematics 105 or 111, and either Physics 102 or 208 or permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs, M W F 10:10. T. G. Owens.
A detailed study of the processes by which plants utilize light energy to grow. Structure of the photosynthetic apparatus, light absorption, photochemistry, and electron transport are emphasized. The course incorporates biophysical, biochemical, physiological, and molecular aspects of photosynthesis. Photosynthetic carbon metabolism is not covered in detail. Discussions include relevant material in bacterial, algal, and higher-plant photosynthesis.]

[446 Plant Cytogenetics
Fall. 3 credits. Limited to 18 students. Prerequisite: Biological Sciences 281 or equivalent. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lecs, M W 9:05; lab, R 2–4:25. J. I. Davis.
An analysis of the cellular mechanisms of heredity, particularly the behavior of chromosomes, and the role of chromosome structure and behavior in plant evolutionary processes. The application of chromosomal studies to analyses of plant species biology and phylogenetics is also covered.]

447 Molecular Plant Systematics
Fall. 3 credits. Prerequisites: Biological Sciences 248, 281, and 330 or 331, or written permission of instructor. Offered alternate years.
Lecs, T R 10 :10–11: 30. J. J. Doyle.
The study of variation at the molecular level and its application to the taxonomy and evolution of plants, primarily angiosperms. Both micromolecules—particularly flavonoids—and macromolecules are discussed. Topics include analysis of electrophoretic and sequence variation of proteins, the use of such variation as a phylogenetic tool, and genome organization and evolution. Major emphasis is placed on the impact of recombinant DNA technology on plant systematics, with comprehensive treatment of the methods involved. The nuclear, chloroplast, and mitochondrial genomes of plants are treated in detail, with discussion of the use of variation patterns discernible at the restriction-enzyme and DNA-sequence levels. Methods of phylogenetic analysis of molecular data are also covered.

[448 Plant Evolution and the Fossil Record
Spring. 3 credits. Prerequisite: Biological Sciences 241 or equivalent, or permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs, T R 9:05; lab, R 12:20–2:15. K. J. Niklas.
An introduction to evolution, surveying major changes in plants from the origin of life to the present. Emphasis is placed on plant form and function, adaptations to particular ecologic settings, and evolutionary theory as it relates to plants.]

450 Optical Methods of Plant Biologists
Spring. 3 credits. Limited to 12 students. Prerequisite: Biological Sciences 444 or permission of instructor.
Lecs, T R 1:25; lab R 2:15–4:30. R. O. Wayne.
Theoretical and practical aspects of light microscopy, including brightfield, darkfield, phase-contrast, polarization, differential-interference-contrast, and fluorescence microscopy, as well as video- and computer-based digital image enhancement, are studied. Students learn both qualitative and quantitative techniques to probe noninvasively the structure and function of living plant cells.

[640 Applied Plant Anatomy
Spring. 3 credits. Prerequisites: Biological Sciences 345 or equivalent, and permission of instructor. Not offered 1989–90.
Lecs and discs, T R 9:05; lab, W 10:10–1:10 or by arrangement with instructor. N. W. Uhl.
The use of anatomy in vascular plants for diagnosis of structure, taxonomic relationships, evolutionary sequences, and ecological adaptions, with emphasis on recent research. The laboratory provides experience in techniques and interpretation.]

641 Laboratory in Plant Molecular Biology
Fall. 4 credits. Prerequisites: Biological Sciences 281 or equivalent, 330 or 331 or equivalent, and permission of instructor. S-U grades optional.
Lab to be arranged. J. B. Nasrallah, M. R. Hanson, S. D. Tanksley, P. Palukaitis.
Selected experiments on genome organization, gene expression, and gene transfer in plants. The course emphasizes the application of molecular biology methodology to plant systems.

[642 Plant Mineral Nutrition (also Agronomy 642)
Spring. 3 credits. Prerequisite: Biological Sciences 341 or equivalent. Offered alternate years. Not offered 1989–90.
Lecs, M W F 10:10. L. V. Kochian, R. M. Welch.
A detailed study of the processes by which plants acquire and use mineral nutrients from the soil. Topics include the uptake, translocation, and compartmentation of mineral elements; root-soil interactions; the metabolism of mineral elements; the involvement of mineral nutrients in various physiological processes; and the nutrition of plants adapted to extreme environmental stresses (e.g., salinity). Specific mineral elements are emphasized to illustrate these topics.]

643 Plant Physiology, Advanced Laboratory Techniques
Fall. 4 credits. Primarily for graduate students in the plant sciences. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. S-U grades only.
Lab, T or W 8–5; disc, M 4:30–5:30. A. T. Jagendorf.
An introduction to some modern methods in experimental plant biology.

644 Plant Growth and Development
Spring. 3 credits. Prerequisites: Biological Sciences 345 and either 242 or 341 or their equivalents, or written permission of instructor. Offered alternate years.
Lecs, M W F 9:05. D. J. Paolillo and staff.
Explores the changes that occur during plant growth and development and their control: morphological and anatomical changes in apices, tissue differentiation, organ formation, embryo development, gene regulation, hormone action and interaction, the influence of light in development, flowering, fruiting, dormancy, abscission, and senescence.

[645 Families of Tropical Flowering Plants
Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades only. Offered alternate years. Not offered 1989–90.
Lec and disc, F 11:15. Bailey Hortorium staff.
The families of flowering plants encountered solely or chiefly in tropical regions are considered in lectures, discussions, and demonstrations, with the aim of providing basic points of recognition for, and an understanding of, diversity and relationships in these families for the student venturing into the tropics.]

[646 Families of Tropical Flowering Plants: Field Laboratory
Intersession. 3 credits. Limited to 20 students, with preference given to graduate students from member institutions of the Organization for Tropical Studies. Prerequisite: Biological Sciences 342 or 248 or equivalent. Recommended: Biological Sciences 645. S-U grades only. For more details and application, contact the L. H. Bailey Hortorium, 467 Mann Library. Offered alternate years. Not offered 1989–90.
Bailey Hortorium staff.
An intensive orientation to families of tropical flowering plants represented in forests of the American tropics. Emphasis on field identification combined with laboratory analysis of available materials in a "whole-biology" context.]

647 Seminar in Systematic Botany
Fall and spring. 1 credit. May be repeated for credit. Prerequisite: written permission of course coordinator required for undergraduates. S-U grades optional.
Sem to be arranged. Bailey Hortorium staff.
Lectures and discussions led by staff, visitors, and students on topics of current importance to systematic botany.

[648 Plant Biochemistry
Spring. 3 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. Offered alternate years. Not offered 1989–90.
Lecs, M W F 9:05. A. T. Jagendorf, R. E. McCarty, J. F. Thompson.
Selected areas of plant biochemistry are reviewed in the context of the plant life cycle and responses to the environment. Topics include metabolism of lipids, carbohydrates, organic acids, and proteins; nitrogen and sulfur assimilation; respiration; photosynthesis; development and replication of chloroplasts; and cell-wall composition and properties. Attention is paid to operation of control mechanisms.]

649 Transport of Solutes and Water in Plants
Fall. 3 credits. Prerequisite: Biological Sciences 341 or equivalent. Offered alternate years.
Lecs, M W F 10:10. R. M. Spanswick.
Transport of ions, water, and organic materials in plants; mechanisms of ion transport; relationships between ion transport and metabolism; ion uptake and transport in higher plants; phloem transport; and water relations of single cells and whole plants.

[651 Quantitative Whole-Plant Physiology
Fall. 3 credits. Prerequisites: introductory physics, calculus, and plant physiology. S-U grades only. Offered alternate years. Not offered 1989–90.
Lecs, T R 10:10–11:30. R. M. Spanswick.
An exploration of the extent to which physiological processes and their interactions can be formulated in a quantitative manner and integrated to describe various aspects of plant behavior, including growth and yield. Consideration is given to characterization of the plant environment, energy balance, gas exchange, water relations, photosynthesis, respiration, translocation, nutrient supply, and the timing of developmental events.]

653 Plant Molecular Genetics (also Plant Breeding 653)
Spring. 3 credits. Prerequisites: Biological Sciences 281, and 330 or 331, or their equivalents.
Lecs, T R 10:10–11:30. S. D. Tanksley, M. R. Hanson, J. B. Nasrallah.
A review of the organization, function, and evolution of genetic information in higher plants. An in-depth treatment of the organization of the chloroplast, mitochondrial, and nuclear genomes as well as their interactions. Current information on gene regulation in higher plants is also discussed.

[654 Plant Nomenclature
Spring. 1 credit. Prerequisite: written permission of instructor. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lec and disc to be arranged. R. P. Korf.
An analysis of the International Code of Botanical Nomenclature and its application to various plant groups.]

656 Topics in Paleobotany
Spring. 1 credit. Prerequisite: Biological Sciences 448 or equivalent background in evolution or written permission of instructor.
Lab and disc to be arranged. K. J. Niklas.
A series of selected topics to provide a background in plant evolution, paleobotanical literature, and evolutionary theory. Among the topics discussed are the origin of a terrestrial flora, the evolution of the seed plants, and the origin and adaptive radiation of the angiosperms.

[657 Literature of Taxonomic Botany
Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lec and disc, R 10:10. Bailey Hortorium staff.
A survey of the basic reference works in taxonomy from the pre-Linnaean literature drawn on by Linnaeus to contemporary publications, with comments on the peculiarities of the books (when appropriate), publication dates, typographic devices, and intricacies of bibliographic citation.]

740 Plant Biology Seminar
Fall and spring. No credit (no official registration). Required of graduate students doing work in plant biology.
Sem, F 11:15. Staff.
Lectures on current research in plant biology, presented by visitors and staff.

742 Current Topics in Plant Molecular Biology
Fall and spring. 1 credit. Limited to 20 students. Primarily for graduate students, with preference given to majors or minors in plant molecular biology; written permission of instructor required for undergraduates. S-U grades only.
Sem, 1 hour each week to be arranged. Staff.
A seminar with critical presentation and discussion by students of original research papers concerning the molecular biology of plants. Staff direction varies each year and is announced a semester in advance.

749 Graduate Research in Botany
Fall or spring. Variable credit. May be repeated for credit. S-U grades optional.
Hours to be arranged. Staff.
Similar to Biological Sciences 499 but intended for graduate students who are working with faculty members on an individual basis.

840 Current Topics in Plant Physiology
Fall or spring. 2 credits. May be repeated for credit. S-U grades only.
Sem to be arranged. Staff.
Seminar reports by graduate students on current literature in experimental plant physiology or related areas.

Related Courses in Other Departments

Marine Botany: Ecology of Marine Plants (Biological Sciences 449)

Introductory Mycology (Plant Pathology 309)

Mycology (Plant Pathology 709)

Mycology Conferences (Plant Pathology 649)

Plant Ecology, Lectures and Laboratory (Biological Sciences 463 and 465)

Plant Ecology Seminar (Biological Sciences 669)

Taxonomy of Fungi (Plant Pathology 729)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

ECOLOGY, SYSTEMATICS, AND EVOLUTION

261 Principles of Ecology (formerly General Ecology)
Fall. 4 credits. Prerequisite: one year of introductory biology. S-U grades optional.
Lecs, M W F 11:15; disc, W or R 1:25, 2:30, or 3:35. R. W. Howarth, P. L. Marks, and D. W. Winkler.
An introduction to principles of ecology concerning the interactions between organisms and their environment. The course deals with both terrestrial and aquatic ecology, including phenomena that occur at the population, community, and ecosystem levels of organization. These principles are brought to bear on a number of current environmental problems.

263 Field Ecology
Fall. 2 credits. Prerequisite: concurrent or previous enrollment in Biological Sciences 261. Limited to 16 students.
Lec, R 1:25; lab, F 12:20–5. One weekend field trip to the Hudson Valley. P. L. Marks.
Field exercises designed to give students direct experience with field work, with emphasis on developing observational skills, journal keeping, and a landscape perspective. Topics include plant succession, niche relationships of insects, influence of herbivores and competition on plant performance, decomposition of soil litter, sampling plankton, and use of scientific collections.

272 Functional Ecology
Spring. 4 credits. Prerequisite: one year of introductory biology for majors. Offered alternate years.
Lecs, M W F 9:05; lab, T or R 1:25–4:25. Evening prelims Feb. 20 and Apr. 3. F. H. Pough.
An introductory course for students interested in how animals work. The features of the physical environment that are important to insects and vertebrates are used to illustrate the interaction of physiological, behavioral, and morphological characteristics in organismal activity and homeostasis. Laboratories include a survey of the diversity of endothermal and ectothermal animals, ecophysiological measurements, and measurements of important environmental parameters in local habitats. This course uses live and preserved vertebrate animals for field observations and laboratory exercises.

[274 Functional and Comparative Morphology of Vertebrates
Spring. 4 credits. Prerequisite: one year of introductory biology. Offered alternate years. Not offered 1989–90.
Lecs, T R 12:20; labs, T R 1:25–4:25. D. K. McClearn.
An exploration of the relations between form and function in biological systems with an emphasis on trends in vertebrate evolution. Lectures integrate data from topics such as locomotion, feeding, size, and scaling with issues of historical importance and current interest (e.g., correlation of body parts, adaptationist explanations, developmental constraints, criteria for determining biomechanical and energetic "efficiency"). Laboratories include dissections of preserved vertebrate animals and noninvasive live animal demonstrations (motion analysis, surface electrode, and force-plate recordings).]

275 Human Biology and Evolution (also Anthropology 275)
Fall. 3 or 4 credits (4 credits with discussion). S-U grades optional, with permission of instructor.
Lecs, M W F 10:10; optional disc to be arranged. K. A. R. Kennedy, J. D. Haas.
An introduction to the biology of *Homo sapiens* through an examination of human evolution, biological diversity, and modes of adaptation to past and present environments. Evolutionary theory is reviewed in relation to the current evidence from the fossil record and studies of the evolution of human behavior. A survey of human adaptation covers a complex of biological and behavioral responses to environmental stress. Human diversity is examined as the product of long-term evolutionary forces and short-term adaptive responses. Topics such as creationism, the Piltdown fraud, the sociobiology debate, genetic engineering, race and IQ, and racism are presented as examples of current issues in human biology. These topics and others are the focus of the optional one-hour weekly discussions.

371 Human Paleontology (also Anthropology 371)
Fall. 4 credits. Prerequisite: one year of introductory biology or Anthropology 101 or permission of instructor. Offered alternate years.
Lecs, M W F 2:30; lab, 1 hour each week to be arranged; occasional field trips. K. A. R. Kennedy.
A broad survey of the fossil evidence for human evolution with special attention to skeletal and dental anatomy, geological contexts, paleoecology, dating methods, archaeological associations, and current theories of primate phylogeny.

[373 The Invertebrates: Form, Function, and Evolution
Fall. 4 credits. Limited to 30 students. Prerequisite: one year of introductory biology for majors. Offered alternate years. Not offered 1989–90.
Lecs, M W F 10:10; lab, W 1:25–4:25; one optional weekend field trip to Shoals Marine Laboratory. Small fee for the field trip. C. D. Harvell.
An introduction to the evolution of form and function among the major invertebrate phyla. Strong emphasis is placed on the integration of evolutionary pasts and ecological presents to produce extant forms. Lectures draw heavily on original literature from the field of invertebrate functional morphology. Laboratory dissections and demonstrations often involve live marine and freshwater invertebrates.]

378 Evolutionary Biology
Spring. 4 credits (2 credits if taken after Biological Sciences 207). Prerequisite: one year of introductory biology or permission of instructor. S-U grades optional.
Lecs, M W F 10:10; disc, 1 hour each week to be arranged. R. G. Harrison.
The course considers explanations for patterns of diversity and for the apparent "good fit" of organisms to the environment. Topics covered include the genetic and developmental basis of evolutionary change, processes at the population level, the theory of evolution by natural selection, levels of selection, concepts of fitness and adaptation, modes of speciation, long-term trends in evolution, rates of evolution, and extinction.

455 Insect Ecology (also Entomology 455)
Fall. 3 credits. Prerequisites: Biological Sciences 261 and Entomology 212 or their equivalents. Offered alternate years.
Lecs, W F 11:15; disc, 1 hour each week to be arranged. R. B. Root.
Ecological and evolutionary principles are integrated by thorough examination of outstanding investigations. Topics include the factors responsible for the great diversity of insects, adaptive syndromes associated with climate, natural history of arthropod guilds, impact of insects on terrestrial vegetation, population regulation, and the contrast between natural and managed ecosystems.

457 Limnology, Lectures (formerly Biological Sciences 462)
Fall. 3 credits. Prerequisite: Biological Sciences 261 or written permission of instructor. Recommended: introductory chemistry.
Lecs M W F 11:15. N. G. Hairston, Jr.
The study of continental waters, with emphasis on lakes and ponds. Factors regulating nutrients, population and community dynamics of freshwater organisms, and physical and chemical properties of fresh water are considered.

459 Limnology, Laboratory (formerly Biological Sciences 464)
Fall. 2 credits. Prerequisite: concurrent or previous enrollment in Biological Sciences 457.
Lab, T W or R 1:25–4:25; 1 weekend field trip. N. G. Hairston, Jr. and staff.
Laboratories and field trips devoted to studies of the biological, chemical, and physical properties of lakes and other freshwater environments. Vertebrate dissection (fish) during one laboratory exercise and during a portion of weekend field trip.

461 Population and Evolutionary Ecology
Spring. 4 credits. Prerequisite: Biological Sciences 261 or 378. S-U grades optional. Offered alternate years. Offered spring 1990; next offered fall 1991 and alternate fall semesters thereafter.
Lecs, M W F 11:15; lab, M 1:25–4:25.
D. W. Winkler and S. A. Levin.
Problems of ecology are viewed from an evolutionary perspective, exploring issues of adaptation and fitness definition by developing advanced understanding of demography and interspecific interactions. Blending theory and empirical findings, the course explores population dynamics; life-history theory; dispersal; competition; predation; parasite-host coevolution; mutualisms; and sexual, kin, and group selection. Methods of estimation and analysis are learned in laboratory.

462 Marine Ecology
Spring. 3 credits. Prerequisite: Biological Sciences 261. Offered alternate years.
Lecs and disc, M W F 10:10.
C. D. Harvell and R. W. Howarth.
Lectures and discussion focus on current research in broad areas of marine ecology with an emphasis on processes unique to marine systems. A synthetic treatment of multiple levels of organization in marine systems including organismal, population, community, ecosystems, and evolutionary biology.

463 Plant Ecology, Lectures
Fall. 3 credits. Prerequisites: two advanced-level courses in biology, including Biological Sciences 261, or permission of instructor. Recommended: some taxonomic familiarity with vascular plants and concurrent enrollment in Biological Sciences 465.
Lecs, M W F 11:15. Staff.
Principles of plant-environment and plant-plant interactions in relation to the evolution, distribution, structure, and functioning of plants and plant communities.

464 Microevolution and Macroevolution (also Entomology 464)
Spring. 4 credits. Limited to 25 students. Prerequisite: Biological Sciences 378 or permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years.
Lecs, T R 10:10–11:30; disc, one hour each week to be arranged.
A. R. McCune and S. Via.
An advanced course in evolutionary biology integrating macroevolutionary and microevolutionary approaches. Areas of emphasis include patterns and processes of speciation, phylogeny reconstruction in populations and higher taxa, the origins and fate of variation, and causes of major evolutionary transitions. Discussion of these problems involve data and approaches from genetics, morphology, systematics, paleobiology, development, and ecology.

465 Plant Ecology, Laboratory
Fall. 1 credit. Prerequisite: concurrent enrollment in Biological Sciences 463.
Lab, F 12:05–5. Staff.
Laboratory and field exercises designed to give firsthand experience with the ecology of plants. Emphasis is on making observations and measurements of plants in the field.

[470 Ecological Genetics (also Entomology 470)
Spring. 4 credits. Prerequisite: Biological Sciences 378 or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lecs, T R 10:10–11:25; disc, one hour each week to be arranged. S. Via.
A study of the relationships between genetic and ecological processes in populations. Topics include consequences of genetic variation in age-structured populations; demographic concepts of fitness; evaluation of methods for measuring genetic variation and natural selection on ecologically important traits; genetics of competitive ability and predator avoidance; genetic and ecological aspects of phenotypic plasticity; character displacement; maintenance of genetic variability; limits to selection. How theory can be used to formulate hypotheses about evolutionary mechanisms in natural populations is considered and experiments designed to test such hypotheses are evaluated.]

471 Mammalogy
Fall. 4 credits. Recommended: Biological Sciences 274. S-U grades optional, with permission of instructor. Offered alternate years. Fee, $15.
Lecs, M W F 9:05; lab, M or T 1:25–4:25; 1 weekend field trip required.
D. K. McClearn.
Lectures on the evolution, classification, distribution, and adaptations of mammals. Laboratory and fieldwork on systematics, ecology, and natural history of mammals of the world, with primary emphasis on the North American fauna. Systematics laboratories held in the museum at Research Park. Live animals are studied in the field and are sometimes used in the laboratory for nondestructive demonstrations or experiments. The systematics laboratory exercises are based on museum specimens.

[472 Herpetology (formerly Biological Sciences 473)
Spring. 4 credits. Recommended: Biological Sciences 274. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1989–90. Fee, $10.
Lecs and labs, T R 12:20–4:25; occasional field trips and special projects.
F. H. Pough.
Lectures cover various aspects of the biology of amphibians and reptiles, including evolution, zoogeography, ecology, behavior, and physiology. Laboratory includes systematics, functional morphology, and behavior. Live animals are studied in the field and are sometimes used in the laboratory for nondestructive demonstrations or experiments. The systematics laboratory exercises are based on museum specimens.]

[474 Laboratory and Field Methods in Human Biology (also Anthropology 474)
Spring. 4 credits. Prerequisite: one year of introductory biology or Anthropology 101 or permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs and labs, T R 10:10–12:05; additional hours to be arranged. Independent research project required.
K. A. R. Kennedy.
Practical exercises and demonstrations of modern approaches to the methodology of physical anthropology. Emphasis on comparative human anatomy, the human paleontological record, description of skeletal and living subjects, paleopathology, skeletal maturation, and relevant field techniques for the archaeologist and forensic anthropologist.]

[475 Ornithology
Fall or summer. 4 credits. Recommended: Biological Sciences 274. S-U grades optional, with permission of instructor. Limited to 30 students. Offered alternate years. Not offered 1989–90. Fee, $15.
Lecs and labs, T R 12:20–4:25; occasional field trips and special projects. Staff.
Lectures cover various aspects of the biology of birds, including anatomy, physiology systematics, evolution, behavior, ecology, and distribution and are fully integrated with laboratory studies. Laboratory includes dissection of dead material, studies of skeletons and plumages, and specimen identification of avian families of the world and species of New York. Independent projects emphasize research skills.]

[476 Biology of Fishes
Fall. 4 credits. Prerequisite: Biological Sciences 274 or equivalent experience in vertebrate zoology with written permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs, M W F 9: 05: lab, M 1:25–4:25.
A. R. McCune.
An introduction to the study of fishes: their structure, evolution, distribution ecology, physiology, behavior, classification, and identification, with emphasis on local species. Live animals are studied in the field and are sometimes used in the laboratory for nondestructive demonstrations or experiments. The systematics laboratory exercises are based on museum specimens.]

[478 Ecosystem Biology
Spring. 4 credits. Prerequisite: Biological Sciences 261 or equivalent. S-U grades optional. Offered alternate years. Not offered 1989–90.

Lecs, T R 10:10–12:05. R. W. Howarth.
Analysis of ecosystems in terms of energy flow and nutrient cycles, emphasizing an experimental approach and comparative aspects of terrestrial, freshwater, and marine ecosystems. Consideration of anthropogenic effects on ecosystems, such as from acid precipitation and offshore oil pollution. Discussion of the interactions between ecosystem processes and community structure.]

[479 Paleobiology (also Geological Sciences 479)
Fall. 3 credits. Prerequisites: one year of introductory biology for majors and either Biological Sciences 274, Geological Sciences 375, Biological Sciences 373, or permission of instructor. Offered alternate years. Not offered 1989–90.

Lecs, M W F 12:20. J. L. Cisne and staff.
A survey of the major groups of organisms and their evolutionary histories. Intended to fill out the biological backgrounds of geology students and the geology backgrouds of biology students concerning the nature and significance of the fossil record for their respective studies.]

660 Field Studies in Ecology and Systematics
Spring. Variable credit. Prerequisites: Biological Sciences 261, a taxon-oriented course, and permission of instructor. Estimated cost of room and board (exclusive of transportation) to be announced.

Lecs and labs to be arranged.
P. L. Marks, R. B. Root.
This course provides students an opportunity to learn techniques and a new biota by participating in an intensive series of field exercises. An extended field trip is scheduled during either intersession or spring break. The region visited, trip objectives, and other details are announced by the instructor in charge in the division's catalog supplement issued at the beginning of the semester. Meetings on campus are devoted to orientation and reports on completed projects.

661 Environmental Policy (also ALS 661 and Biology and Society 461)
Fall and spring. 2 or 3 credits each term. Limited to 12 students. Prerequisite: permission of instructor.

Sem, R 2:30–4:30. D. Pimentel.
This course uses an interdisciplinary approach to focus on complex environmental and energy problems. Ten to twelve students, representing several disciplines, investigate significant environmental problems. The research team spends two semesters preparing a scientific report for publication in *Science* or *BioScience*.

[662 Mathematical Ecology (also Statistics and Biometry 662)
Spring. 3 credits. Prerequisites: one year of calculus and a course in statistics. Recommended: a general ecology course. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1989–90.

Lecs, M W F 12:20. S. A. Levin, C. E. McCulloch.
Mathematical and statistical analysis of populations and communities: theory and methods. Spatial and temporal pattern analysis. Deterministic and stochastic models of population dynamics. Model formulation, parameter estimation, simulation, and analytical techniques.]

664 Seminar in Insect-Plant Interactions (also Entomology 664)
Spring. 2 credits. Intended for seniors and graduate students. Limited to 15 students. Prerequisites: courses in entomology, ecology, evolution, and organic chemistry and written permission of instructor. S-U grades optional. Offered alternate years.

Sem, 1 evening each week to be arranged. P. P. Feeny.
Presentations and discussions by students on the evolution of patterns of interaction between plants and insects, emphasizing critical evaluation of concepts and evidence.

[665 Limnology Seminar
Spring. 1 credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional. Offered alternate years. Not offered 1989–90.

Sem to be arranged. N. G. Hairston, Jr.
A seminar course on advanced limnological topics.]

[668 Comparative Biogeochemistry
Fall. 4 credits. Prerequisites: Solid background in ecology, environmental chemistry, or related environmental science. Permission of instructor required for undergraduates. S-U grades optional. Offered alternate years. Not offered 1989–90. Next offered fall 1990, spring 1992, and alternate spring semesters thereafter.

Lecs and disc, T R 10:10–12:05. R. W. Howarth.
Lectures cover the biotic controls on the chemistry of the environment. Emphasis is on cycles of major elements and minor elements globally and in selected ecosystems, stressing the coupling of element cycles. A comparative approach is used to illustrate similarities and differences in element cycling among ecosystems, with slight emphasis on aquatic ecosystems. Analysis of both theoretical and applied issues, including global atmospheric changes and factors controlling the acidification of lakes.]

669 Plant Ecology Seminar
Spring. 1 credit. May be repeated for credit. Suggested for students majoring or minoring in plant ecology. S-U grades optional.

Sem to be arranged. Staff.
Includes review of current literature, student research, and selected topics of interest to participants.

670 Graduate Seminar in Vertebrate Biology
Fall or spring. 1 credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades only.

Sem to be arranged. Staff.
Seminar presentations and discussions by students on areas of current research in vertebrate biology. Topics vary from semester to semester.

[673 Human Evolution: Concepts, History, and Theory (also Anthropology 673)
Fall. 3 credits. Prerequisite: one year of introductory biology, Anthropology 101, or permission of instructor. Offered alternate years. Not offered 1989–90.

Sem, W 7:30–9:30 p.m.; additional hours to be arranged. K. A. R. Kennedy.
The historical background of present-day concepts of man's evolutionary variations and adaptations in space and time is surveyed. The formation of biological anthropology as an area of scientific inquiry within the social and biological sciences is reviewed.]

674 Principles of Systematics (also Entomology 674)
Spring. 4 credits. Limited to 15 students. Prerequisite: permission of instructor. Recommended: an introductory biological systematics course. Offered alternate years.

Lecs, discs, and labs, M W 1:25–4:25. Q. D. Wheeler and staff.
An introduction to modern theory and methods of systematic biology. Lectures are on theoretical systematics and include species concepts, classification, phylogenetics, and biogeography. Laboratories include modern methods of analysis of data, including cladistic hand and computer methods and numerical methods. Laboratory grade is based in part on a final paper.

760 Special Topics in Evolution and Ecology
Fall or spring. 1–3 credits. May be repeated for credit. Enrollment limited. S-U grades optional, with permission of instructor.

Hours to be arranged. Staff.
Independent or group intensive study of special topics of current interest. Content varies and is arranged between student and staff member.

[765 Autecology/Population Ecology
Fall. 4 credits. Prerequisite: Biological Sciences 261 or equivalent. S-U grades optional. Not offered 1989–90.

Lecs and discs, T R 10:10–12:05. Staff.
Comparison of the responses and adaptations of organisms to environments in selected ecosystems. Emphasis on similarities and differences in molecular and organismal mechanisms by which plants and animals cope with their environments. Critical examination of the properties and dynamics of populations. Emphasis on theories of adaptation, population structures, dynamics, and regulation.]

[766 Communities and Ecosystems
Spring. 4 credits. Prerequisite: Biological Sciences 261 or equivalent. S-U grades optional. Not offered 1989–90.

Lecs, T R 10:10–12:05. Staff.
Structure, dynamics, and evolution of natural communities; species diversity; niches and gradient relations; and succession, climax, and disturbance. Comparative aspects of terrestrial, marine, and freshwater communities. Analysis of ecosystems in terms of energy flow, biogeochemistry, and model systems. Emphasis on functional and structural properties of communities and ecosystems.]

767 Current Topics in Ecology and Evolutionary Biology
Fall. 4 credits. Prerequisites: Biological Sciences 261 and 378 or their equivalents. S-U grades optional.
Lecs and discs, T R 10:10–12:05. Staff.
Critical evaluation and discussion of theory and research in ecology and evolutionary biology. Lectures by faculty and student-led discussions of topics in areas of current importance.

Related Courses in Other Departments

Advanced Soil Microbiology (Agronomy 666)

Advanced Work in Parasitology (Veterinary Medicine 737)

Animal Social Behavior (Biological Sciences 427)

Biology of Plant Species (Biological Sciences 442)

Early People: The Archaeological and Fossil Record (Anthropology 203 and Archaeology 203)

Marine Sciences Courses (Biological Sciences 363–370, 467, 477)

Plant Geography (Biological Sciences 440)

Related Courses in Entomology (Entomology 212, 331, 332, 370, 453, 471, 621, 631, 633, 634, 636, 672)

Related Courses in Natural Resources (Natural Resources 270, 302, 430, 603)

Soil Microbiology, Lectures (Agronomy 476)

Taxonomy of Vascular Plants (Biological Sciences 248)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

Undergraduate Seminar in Biology (Biological Sciences 400)

Veterinary Parasitology (Veterinary Medicine 510)

GENETICS AND DEVELOPMENT

281 Genetics
Fall or spring. 5 credits. Not open to freshmen in fall semester. Enrollment may be limited to 200 students. Prerequisite: one year of introductory biology or equivalent. Students who have taken Biological Sciences 282 may register only with written permission of instructor. No admittance after first week of classes.
Lecs, T R 10:10–12:05; lab, M T W or R 2:30–4:25; additional hours to be arranged. Labs may also be scheduled T or R 8–9:55, W or F 10:10–12:05, F 2:30–4:25, or S 10:10–12:05 if enrollment requires it. Students do not choose lab sections during course enrollment; lab assignments are made during first day of classes. T. D. Fox, M. L. Goldberg, R. J. MacIntyre.
A general study of the fundamental principles of genetics in eukaryotes and prokaryotes. Discussions of gene transmission, gene action and interaction, gene linkage and recombination, gene structure, gene and chromosome mutations, genetic aspects of differentiation, genes in populations, breeding systems, and extrachromosomal inheritance. Aspects of recombinant DNA technology are discussed. In the laboratory, students perform experiments with microorganisms and conduct an independent study of inheritance in *Drosophila*.

282 Human Genetics
Spring. 2 or 3 credits (2 credits if taken after Biological Sciences 281). Each discussion limited to 25 students. Prerequisite: one year of introductory biology or equivalent; written permission of instructor required for students who have taken Biological Sciences 281.
Lecs, M W 10:10; disc, R 10:10 or F 10:10 or 11:15. R. A. Calvo.
A course designed primarily for nonmajors. Lectures provide the technical background needed to understand controversial personal, social, and legal implications of modern genetics that are discussed in section meetings.

385 Developmental Biology
Fall. 3 credits. Prerequisite: Biological Sciences 281.
Lecs, M W F 11:15. A. W. Blackler.
An introduction to the morphogenetic, cellular, and genetic aspects of the developmental biology of animals.

389 Embryology
Spring. 4 credits. Prerequisites: one year of introductory biology and a knowledge of mammalian adult anatomy. Limited to seniors.
Lecs, T R 10:10; labs, T R 2–4:25. A. W. Blackler.
A course in the embryonic development of vertebrate animals, with emphasis on the comparative aspects of morphogenesis and function at the tissue level. The laboratory has a strong morphogenetic bias, emphasizing the comparative aspects of developmental anatomy. Preserved materials are used in the laboratory.

480 Seminar in Developmental Biology
Spring. 1 credit. May be repeated for credit. Limited to upperclass students. S-U grades only.
Sem to be arranged. Staff.

481 Population Genetics
Fall. 4 credits. Prerequisite: Biological Sciences 281 or equivalent.
Lecs, M W F 10:10; disc, M 2:30 or T 1:25. C. F. Aquadro.
A study of factors that influence the genetic structure of Mendelian populations and that are involved in race formation and speciation. Topics include the diversity and measurement of genetic variation, mating and reproductive systems, selection and fitness, genetic drift, migration and population structure, mutation, multilocus models, the genetics of speciation, quantitative traits, and the maintenance of molecular variation. The interplay between theory and the data from experiments and natural populations are emphasized.

482 Human Genetics and Society
Fall. 2 credits. Prerequisites: Biological Sciences 281 and 330 or 331. Enrollment limited to senior biological sciences majors, with preference given to students studying genetics and development.
Disc, T 2:30–4:25. R. A. Calvo, H. T. Stinson.
Presentation of the technology and discussion of the ethical, social, and legal implications of recent advances in human genetics. Among the topics that may be considered are new reproductive strategies, wrongful life and wrongful birth, eugenics, genetic counseling, genetic screening (prenatal, neonatal, presymptomatic, carrier, and workplace), genetic effects of abused substances, sociobiology, and gene therapy. Students lead most discussions.

483 Molecular Aspects of Development
Spring. 3 credits. Prerequisites: Biological Sciences 281, 330 or 331, and 385. Offered alternate years.
Lecs, T R 10:10–11:45. M. F. Wolfner.
An examination of the molecular biology of developing systems, with emphasis on the genomic, transcriptional, post-transcriptional, translational, and post-translational mechanisms involved in regulating development. Both prokaryotic and eukaryotic systems are considered, but emphasis is on the latter. Topics to be discussed include changes in chromatin structure, DNA rearrangements, control of RNA synthesis and processing, translational controls, nucleo-cytoplasmic interactions, and genetic responses to hormone treatment. The regulation of selected developmental systems is considered in detail.

484 Molecular Evolution
Spring. 3 credits. Prerequisites: Biological Sciences 281 and organic chemistry. Offered alternate years.
Lecs, T R 11:15. R. J. MacIntyre.
An analysis of evolutionary changes in proteins and nucleic acids, and gene-enzyme variability in natural populations. Theories on the evolution of the genetic code and the construction of phylogenetic trees from biochemical data are discussed. The second half of the course concerns the evolution and the organization of genomes from viruses to higher eukaryotes.

485 Microbial Genetics, Lectures
Fall. 2 credits. Limited to upperclass and graduate students. Prerequisites: Biological Sciences 281 and Microbiology 290, or written permission of instructor. S-U grades optional.
Lec, W 7:30–9:25 p.m. S. A. Zahler.
Genetics of bacteria and their viruses, with emphasis on the mechanisms of genetic phenomena.

486 Immunogenetics (also Animal Science 486)
Fall. 3 credits. Limited to seniors and graduate students. Prerequisites: an introductory course in genetics, prior or concurrent enrollment in basic immunology, or written permission of instructor. Offered fall 1989; next offered fall 1991.
Lecs and discs, M W F 10:10. R. R. Dietert.
The genetic control of a variety of cellular antigens and their use in understanding biological and immunological functions. The genetics of antibody diversity, antigen recognition, immune response, transplantation, and disease resistance are discussed

487 Microbial Genetics, Laboratory
Fall. 3 credits. Primarily for upperclass students. Limited to 16 students. Prerequisites: concurrent or previous enrollment in Biological Sciences 485, Microbiology 291 or equivalent, and written permission of instructor.
Lab, T 1:25–4:25; additional hours to be arranged. S. A. Zahler.
Problem solving in bacterial genetics.

686 Mammalian Development
Spring. 2 credits. Limited to 25 students. Prerequisites: Biological Sciences 281 and 385 or their equivalents. S-U grades optional. Offered alternate years.
Lecs, W F 11:15. W. H. Mark.
An in-depth study of mammalian development using the mouse as the animal model. The course covers classical embryology beginning with gametogenesis followed by morphogenetic and biochemical anayses of pre- or post-implantation development. Current topics in experimental embryology, including genetic analysis of mutants, study of cell lineage with chimeras, in vitro culturing of embryonic stem cells, and molecular approaches to understanding development are examined.

[687 Developmental Genetics
Fall. 2 credits. Limited to 20 students. Prerequisites: Biological Sciences 281 or equivalent, Biological Sciences 385 or equivalent. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lec, M 7:30–9:30 p.m. K. J. Kemphues.
Selected topics focus on the use of genetic analysis in understanding mechanisms of development. Topics are drawn primarily from studies in *Drosophila, Caenorhabditis,* and Mouse. Other possible topics include pattern formation, cell lineage, neural development, maternal information in development, germ cell development, sex determination, and intercellular communication. Students read current literature and are given the opportunity to discuss each topic in class.]

688 Yeast Genetics
Spring. 2 credits. Prerequisites: Biological Sciences 281, 330 or 331, and 485, or written permission of instructor. S-U grades optional.
Lecs, W 7:30–9:25 p.m. T. D. Fox.
An advanced overview of genetic studies in yeast, primarily *Saccharomyces cerevisiae.* Both formal genetic and molecular approaches to selected problems of biological interest are discussed.

[689 Advanced Topics in Population Genetics
Fall. 2 credits. Limited to 20 students. Prerequisites: Biological Sciences 481 or equivalent and written permission of instructor. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lec, T 2:30–4:25. C. F. Aquadro.
An in-depth exploration of current areas of research in population genetics. Readings primarily from recent books and the current literature. Specific topics announced the previous spring and in the division's catalog supplement. Format includes lectures, discussion, and presentations by students.]

780 Current Topics in Genetics
Fall and spring. 2 credits. May be repeated for credit. Primarily for graduate students, with preference given to majors in the Field of Genetics; written permission of instructor required for undergraduates. Limited to 20 students. No auditors. S-U grades optional, with permission of instructor.
Sem to be arranged. Staff.
A seminar course with critical presentation and discussion by students of original research papers in a particular area of current interest. Content of the course and staff direction vary each year and are announced a semester in advance.

781 Problems in Genetics and Development
Fall. 1 credit. Limited to first-year graduate students in the Field of Genetics.
Disc to be arranged. Staff.
An introduction to the research literature in selected areas through weekly problem sets and discussions.

782–787 Current Genetics/Development Topics
Fall or spring. 1/2 or 1 credit for each topic. May be repeated for credit. S-U grades only.
Lectures and seminars on specialized topics to be announced.

Related Courses in Other Departments

Animal Cytogenetics (Animal Science 419)

Animal Development (Veterinary Medicine 507)

Current Topics in Biochemistry (Biological Sciences 731–736)

Laboratory in Plant Molecular Biology (Biological Sciences 641)

Evolutionary Biology (Biological Sciences 378)

Plant Growth and Development (Biological Sciences 644)

Plant Molecular Genetics (Biological Sciences 653)

Reproduction and Development of Marine Invertebrates (Biological Sciences 488)

Undergraduate Research in Biology (Biological Sciences 499)

NEUROBIOLOGY AND BEHAVIOR

221 Neurobiology and Behavior I: Introduction to Behavior
Fall. 3 or 4 credits (4 credits with discussion and written projects). 4–credit option required of students studying neurobiology and behavior. Each discussion limited to 20 students, with preference given to students studying neurobiology and behavior. Not open to freshmen. Prerequisite: one year of introductory biology for majors. May be taken independently of Biological Sciences 222. S-U grades optional.
Lecs, M W F 12:20; disc to be arranged. P. W. Sherman and staff.
A general introduction to the field of behavior. Topics include evolution and behavior, behavioral ecology, sociobiology, chemical ecology, communication, neuroethology, rhythmicity, orientation and navigation, and hormonal mechanisms of behavior.

222 Neurobiology and Behavior II: Introduction to Neurobiology
Spring. 3 or 4 credits (4 credits with discussion and written projects). 4–credit option required of students studying neurobiology and behavior. Each discussion limited to 20 students, with preference given to students studying neurobiology and behavior. Not open to freshmen. Prerequisites: one year of introductory biology for majors and one year of chemistry. May be taken independently of Biological Sciences 221. S-U grades optional.
Lecs, M W F 12:20; disc to be arranged. A. H. Bass and staff.
A general introduction to the field of cellular and integrative neurobiology. Topics include neural systems, neuroanatomy, developmental neurobiology, electrical properties of nerve cells, synaptic mechanisms, neurochemistry, motor systems, sensory systems, learning, and memory.

322 Hormones and Behavior (also Psychology 322)
Spring. 3 or 4 credits; the 4-credit option involves a one-hour section once a week, in which the students are expected to participate in discussion and read original papers in the field. *Because the 4-credit option has very limited enrollment, students should preregister for 3 credits only.* Limited to juniors and seniors; open to sophomores only by permission. Prerequisites: one year of introductory biology plus a course in psychology or Biological Sciences 221 or 222. S-U grades optional.
Lecs, T R 10:10–11:30; disc to be arranged. E. Adkins Regan, R. E. Johnston.
The relationship between endocrine and neuroendocrine systems and the behavior of animals, including humans. Major emphasis is on sexual, parental, and aggressive behavior.

324 Biopsychology Laboratory (also Psychology 324)
Fall. 4 credits. Limited to 24 upperclass students. Prerequisites: laboratory experience in biology or psychology, Biological Sciences 221 and 222 or Psychology 123 and 222; and permission of instructor. S-U grades optional.
Labs, T R 1:25–4:25. T. DeVoogd.
Experiments designed to provide research experience in animal behavior (including learning) and its neural and hormonal mechanisms. A variety of techniques, species, and behavior patterns are included. Live animals are used in the laboratory.

[326 The Visual System
Spring. 4 credits. Prerequisites: Biological Sciences 222 or 311, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1989–90; next offered 1991–92.
Lecs, M W F 10:10; disc, 1 hour each week to be arranged. H. C. Howland.
The visual systems of vertebrates and invertebrates are discussed in breadth and depth. Topics covered include the optics of eyes, retinal neurophysiology, and structure and function of higher visual centers.]

396 Introduction to Sensory Systems (also Psychology 396)
Spring. 3 or 4 credits (4 credits with discussion and term paper). No auditors. Prerequisites: an introductory course in biology or biopsychology, and a second course in neurobiology or behavior or perception or cognition or biopsychology; students are expected to have elementary knowledge of perception, neurophysiology, behavior, and chemistry. Permission of instructor required for 4-credit option. Offered alternate years.
Lecs, M W F 9:05. B. P. Halpern.
This course employs the Socratic method, in which the instructor asks questions of the students. Students read, analyze, and discuss in class difficult original literature dealing with both those characteristics of sensory systems that are common across living organisms and those sensory properties that represent adaptations of animals to particular habitats or environments. The principles and limitations of major methods used to examine sensory systems are considered. General principles of sensory systems and auditory, visual, and somesthetic systems are covered. One aspect of each system (e.g., localization of objects in space by sound, color vision, and thermoreception) is selected for special attention. At the level of *An Introduction to the Physiology of Hearing*, by J. O. Pickles; *Photoreceptors: Their Role in Vision*, by A. Fein and E. Z. Szuts; *Comparative Studies of Hearing in Vertebrates*, edited by A. N. Popper and R. R. Ray; and "Information Processing in Cutaneous Mechanoreceptors," Federation Proceedings 42:1983.

420 Topics in Neurobiology and Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for undergraduates. S-U grades optional.
To be arranged. Staff.
Courses on selected topics in neurobiology and behavior; can include lecture and seminar courses. Topics, instructors, and time of organizational meetings are listed in the division's catalog supplement issued at the beginning of the semester.

424 Neuroethology
Fall. 3 credits. Prerequisites: Biological Sciences 221 and 222. S-U grades optional for graduate students only. Offered alternate years.
Lecs, M W 11:15; disc, F 11:15.
C. D. Hopkins.
The integrated study of neurobiology and animal behavior. Representative topics include acoustic communication in insects and amphibians, vocal mechanisms and plasticity of bird song, mammalian hearing, bat echolocation, prey detection by owls, electroproduction and electroreception in fish, neurophysiology and behavior of pheromone communication, neurobehavior of vision in anurans, mammalian visual processing, command neurons and decision networks, locomotion and motor-pattern generation, escape behavior in invertebrates, and neural correlates of learning. Assigned readings include original articles in the scientific literature. A term paper on the neural basis of animal behavior is required.

[426 Electronics for Neurobiology
Spring. 3 credits. Limited to 20 students. Prerequisites: Biological Sciences 222 and one year of introductory physics. Offered alternate years. Not offered 1989–90.
Lecs, T R 9:05; lab, 4 hours each week to be arranged. D. W. McBride.
Electronics as applied to electrophysiological instrumentation, data acquisition, and analysis. Topics include a review of basic electrical concepts, the cell as a circuit, design of amplifiers and pulse generators for biological use, and computer interfacing to an experiment.]

[427 Animal Social Behavior
Fall. 3 credits. Limited to 30 students. Prerequisites: Biological Sciences 221 and 261. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1989–90.
Lecs and discs, T R 2:30–4:20.
S. T. Emlen.
An intensive course for upper-division students interested in the adaptive bases of social behavior. Lectures, discussions, and student presentations examine topics including spacing systems, mating systems, sexual selection, mate choice, conflict and cooperation in animal societies, and the evolution of deceit, honesty, and altruism.]

[428 Mechanisms of Animal Behavior: Field and Laboratory Studies
Spring. 3 credits. Limited to 15 students. Prerequisite: Biological Sciences 221. S-U grades optional, with permission of instructor. Not offered 1989–90; next offered 1991–92.
Lecs and discs, T R 2:30–4:20.
K. K. Adler.]

[429 Olfaction and Taste: Structure and Function (also Psychology 429)
Fall. 3 or 4 credits (4 credits with term paper on research project, which can, but need not, study nonhuman vertebrates). Prerequisite: a 300-level course in biopsychology or equivalent. Preference given to junior and senior psychology and biology majors and graduate students. S-U grades optional for graduate students only. Offered alternate years. Not offered 1989–90.
Lecs, T R 9:05. B. P. Halpern.
The structural and functional characteristics of olfaction and taste are explored by reading and discussing current literature in these areas. Structure is examined at the light- and electron-microscope levels, as well as at the molecular level. The neurophysiological and biochemical aspects of function are considered. The emphasis of the course is on vertebrates, especially air-breathing vertebrates in the case of olfaction, although there is some coverage of invertebrate forms.]

491 Principles of Neurophysiology
Fall. 4 credits. Limited to 20 students. Prerequisite: Biological Sciences 222 or written permission of instructor. S-U grades optional.
Lecs, M W 10:10; lab, M W 12:20–4:25; additional hours to be arranged.
B. R. Johnson.
A laboratory-oriented course designed to teach the theory and techniques of modern cellular neurophysiology. Lecture time is used to present laboratory exercise results, to supplement laboratory topics, and to encourage discussion of primary research papers. Laboratory topics include electrical modeling of neurons; intracellular and extracellular recording, and analysis of neuronal properties such as nerve conduction velocities, resting potentials, electrical synaptic transmission; voltage-clamp analysis of ionic currents; and neuronal architecture. A variety of preparations, both invertebrate and vertebrate, are used as model systems. Computer acquisition and analysis of laboratory results are emphasized.

[492 Sensory Function (also Psychology 492)
Spring. 4 credits. Prerequisite: Biological Sciences 222 or 311 or an upper-level course in biopsychology, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1989–90; next offered 1990–91.
Lecs, M W F 10:10; disc, 1 hour each week to be arranged. H. C. Howland, B. P. Halpern.
Classical topics in sensory function such as vision, hearing, touch, and balance, as well as some more modern topics, including sensory coding, location of stimulus sources in space, and the development of sensory systems. Both human and nonhuman systems are discussed. In all cases the chemical, physical, and neurophysiological bases of sensory information are treated and the processing of this information is followed into the central nervous system. At the level of *The Senses*, edited by Barlow and Mollon, and *An Introduction to the Physiology of Hearing*, by Pickles.]

[493 Developmental Neurobiology
Fall. 3 credits. Prerequisite: Biological Sciences 222 or permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1989–90; next offered 1990–91.
Lecs, T R 9:05; disc to be arranged.
R. Booker.
Lectures covering the development of the nervous system taking examples from both vertebrates and invertebrates. Emphasis is on cellular and molecular issues, that is, How do nerve cells differentiate both morphologically and biochemically? The role of cues such as hormones and developmental genes in neural development are discussed. Readings are taken from original journal articles.]

[494 Comparative Vertebrate Neuroanatomy (formerly Biological Sciences 694)
Spring. 3 credits. Intended for juniors, seniors, and graduate students. Prerequisite: Biological Sciences 222 or equivalent. S-U grades optional. Offered alternate years. Not offered 1989–90.
Lecs, T R 10:10–11:30. A. H. Bass.
Organization and evolution of neuroanatomical pathways as substrates for species-typical vertebrate behaviors. The course is divided into two major sections: principles of brain organization and vertebrate brain evolution.]

495 Membrane Ion Channels
Spring. 3 credits. Limited to 15 students. Prerequisites: Biological Sciences 222, college introductory physics, and calculus, or permission of instructor. S-U grades optional. Offered alternate years.
Lecs, M W F 10:10. O. P. Hamill.
The functional and mechanistic aspects of membrane ion channels, beginning with basic concepts and model systems. Theories of ion permeation and channel gating are discussed. Development of membrane ion channels during neuron differentiation and the role of membrane channels in disease states are also considered.

497 Neurochemistry and Molecular Neurobiology
Fall. 3 credits. Limited to 30 students. Prerequisites: Biological Sciences 222 and either 330 or 331, or permission of instructor. S-U grades optional. Offered alternate years.
Lecs, T R 9:05; disc, T 10:10.
T. R. Podleski.
This course focuses primarily on synaptic neurochemistry. The presynaptic regulation of release and postsynaptic mechanism of action of the major classes of neurotransmitters are discussed, as well as selected neuromodulators and hormones. Second-messenger mechanisms are stressed. Readings are primarily from journal articles.

623 Chemical Communication (also Chemistry 622)
Fall. 3 credits. Primarily for research-oriented students. Limited to 30 students. Prerequisites: one year of introductory biology for majors or equivalent, course work in biochemistry, and Chemistry 358 or equivalent. Offered alternate years.
Lecs, M W F 1:25. T. Eisner, J. Meinwald, W. L. Roelofs, and guest speakers.
The production, transmission, and reception of chemical signals in communicative interactions of animals, plants, and microorganisms. Studies of insects are emphasized. Specific topics are treated with varying emphasis on chemical, biochemical, ecological, behavioral, and evolutionary principles.

[626 Sex Differences in Brain and Behavior (also Psychology 524)
Spring. 2 credits. Limited to 12 students. Prerequisite: Biological Sciences 322 or permission of instructor. Not offered 1989–90.
Disc and sem, M W 3:35–5:30.
T. DeVoogd.
A survey of the newly discovered animal models for sex differences in the brain. Topics include the role of steroids in brain development, whether hormones can modify the structure of the adult brain, and the consequences of such sex differences in anatomy for behavior.]

628 Computer Interfacing for Neurobiologists
Spring. 3 credits. Limited to 20 students. Prerequisites: Biological Sciences 222 and 426, or permission of instructor. S-U grades optional. Offered alternate years.
Lecs, T R 9:05; lab, 4 hours each week to be arranged. D. W. McBride.
Lectures and laboratories deal with interfacing a computer with an experiment and doing data acquisition and computer control of the experiment. Topics include introduction to digital electronics, data acquisition and monitoring of an experiment (A/D conversions and digital input), some data analysis and decision making, computer control of an experiment (D/A conversions and digital output), communication (RS-232 and IEEE), assembler language programming, sampling theory and Fourier analysis, feedback control using computers, optimizing data through-put, and storage to disk. A Mac II computer is used in this course.

720 Seminar in Advanced Topics in Neurobiology and Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional.
Sem to be arranged. Staff and students.
Designed to provide several study groups each semester on specialized topics. A group may meet for whatever period is judged adequate to enable coverage of the selected topics. Ordinarily, topics are selected and circulated during the preceding semester. Discussion of current literature is encouraged. Suggestions for topics should be submitted by faculty or students to the chair of the Section of Neurobiology and Behavior.

721 Graduate Survey of Behavior
Fall. 1 credit. Limited to graduate students. Concurrent registration in Biological Sciences 221 is *not* required. S-U grades optional.
Sem to be arranged. P. W. Sherman and staff.
A survey course involving readings of the original literature in behavior. A weekly seminar, primarily in the form of student-led discussions, is held to discuss readings linked to the material presented in Biological Sciences 221.

722 Graduate Survey of Neurobiology
Spring. 1 credit. Limited to graduate students. Concurrent registration in Biological Sciences 222 is *not* required. S-U grades optional.
Sem to be arranged. A. H. Bass and staff.
A survey course involving readings of the original literature in neurobiology. A weekly seminar, primarily in the form of student-led discussions, is held to discuss readings linked to the material presented in Biological Sciences 222.

723 Advanced Topics in Animal Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students in behavior. Prerequisite: permission of instructor. S-U grades optional.
Sem to be arranged. Staff.
A seminar on a specific topic in animal behavior. The instructor presents lectures during the first few course meetings; the remainder of the course is devoted to student presentations. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

724 Field Methods in Animal Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students in behavior. Prerequisite: permission of instructor. S-U grades optional.
Sem and fieldwork to be arranged. Staff.
A seminar-field experience course designed for first-year graduate students in animal behavior. Weekly seminars discussing field methodology, data collection, and hypothesis testing are followed by an intensive period (ten days to two weeks) in the field. Specific topics and field sites vary from semester to semester. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

790 Advanced Topics in Cellular and Molecular Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Limited to graduate students and advanced undergraduates studying neurobiology and behavior. Prerequisite: Biological Sciences 222. S-U grades optional.
Lecs and sem to be arranged. Staff.
A lecture-seminar course on selected topics in cellular and molecular neurobiology. Students read original papers in the scientific literature and lead discussions of these articles. Suggestions for topics may be submitted by faculty or students to the chair of the Section of Neurobiology and Behavior. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

792 Advanced Laboratory in Cellular and Molecular Neurobiology
Fall or spring. 2 credits. May be repeated for credit. Primarily for graduate students. Prerequisites: Biological Sciences 330 or 331 or equivalent, 491 or equivalent, and written permission of instructor. S-U grades optional.
Lab to be arranged. Staff.
A two-week intensive laboratory course designed to provide experience with a specific technique currently used in cellular and molecular neurobiology. The technique under study and instructor in charge vary from semester to semester and are listed in the division's catalog supplement issued at the beginning of the semester.

793 Advanced Topics in Integrative Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional.
Lecs and discs to be arranged. Staff.
A course designed to provide in-depth knowledge of current research in anatomical and physiological bases of vertebrate and invertebrate behavior. Readings are primarily from specialty books and selected journal articles. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

794 Advanced Laboratory Techniques in Integrative Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Prerequisite: permission of instructor based upon a personal interview.
Lab to be arranged. Staff.
A laboratory in the integrative, or neuroethological, approach to studies of animal behavior. Designed to provide practical working knowledge of research methods in anatomical, physiological, and behavioral approaches to studies of vertebrate and invertebrate behavior. Laboratory technique to be covered and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

Related Courses in Other Departments

Animal Behavior (Psychology 535)

Biochemistry and Human Behavior (Psychology 361 and Nutritional Sciences 361)

Brain and Behavior (Psychology 425)

Developmental Biopsychology (Psychology 422)

Evolution of Human Behavior (Psychology 326)

Human Behavior: A Sociobiological Perspective (Anthropology 476)

Insect Behavior Seminar (Entomology 662)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

COURSES IN MARINE SCIENCES

Although there is no concentration (program in study) in marine sciences offered to Cornell undergraduates, there is extensive opportunity at the undergraduate level to prepare for more advanced study. Students interested in the marine sciences may enroll in courses offered at Cornell's Shoals Marine Laboratory (SML), a seasonal field station located on ninety-five acre Appledore Island, six miles off the Maine and New Hampshire coasts.

The Ithaca campus functions of the Shoals Marine Laboratory are centered in the Cornell Marine Programs Office, G14 Stimson Hall. The office serves as an advising center for students interested in the marine sciences, maintains a browsing library with updated information on graduate study and career opportunities as well as on marine programs at other institutions, and administers the SEA Semester, a 17-credit program offered in cooperation with the Sea Education Association.

The following marine sciences courses are currently administered by the Cornell Marine Programs Office.

204 Biological Illustration
Summer. No credit or 1 credit. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, supplies, and ferry transportation), $500.

Daily sessions for 1 week. SML faculty.
General discussion of scientific publishing, illustration labeling, color techniques, and printing processes. The course provides the scientist or science student a chance to experience several illustration techniques with the goal of obtaining an overview of scientific and wildlife illustrations. The student may choose a single technique to explore in depth. Course size is limited so that individual attention can be emphasized.

306 Marine Microbial Ecology
Summer. 2 credits. Prerequisites: one year of introductory college biology and chemistry. Recommended: an introductory course in microbiology. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,100.

Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.
Designed to provide a strong practical and theoretical understanding of the ecology, physiology, and systematics of marine microbes from diverse marine ecosystems. Intertidal zone, salt marsh, coastal water, open ocean, and hydrothermal vent communities are covered. Particular cellular arrangements, metabolic pathways, and biogeochemical cycles are covered in detail, as are general principles concerning microbial ecology and evolution.

309 Bioclimatology: A Field Introduction
Summer. 2 credits. Prerequisite: one year of college level biology; background preferred in physics/physical geography. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $975.

Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.
A study of the fundamentals of organism-environment interaction developed through defining and measuring abiotic factors including solar radiation, temperature, atmospheric moisture, precipital wind, and currents. In-site exploration of the dynamics of meteorology and the role of abiotic and biotic factors in the life of coastal and marine plants and animals including humans.

329 Ecology of Animal Behavior
Summer. 2 credits. Prerequisite: one year of introductory college biology. Recommended: course work in ecology, evolution, or behavior. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N. H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,100.

Daily lecs and fieldwork for 2 weeks. SML faculty.
The ecological significance of behaviors of coastal organisms, with emphasis on field and laboratory research methods. Lectures and readings address the major subareas of behavior (communication, orientation, social behavior, foraging, predator avoidance, and sensory mechanisms). Each student engages in short-term behavioral observation and prepares a research proposal for studying a problem within the course subject area. Dissection of vertebrate animals will be a part of one or more laboratory sessions.

363 Marine Biology for Teachers
Summer. 1 credit. Primarily for teachers, grades 6 through 12, but open to others. Prerequisite: one year of introductory college biology. S-U grades optional. A special 10-day course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $750.

Daily lecs, labs, and fieldwork for 10 days. SML faculty.
Designed to give an overview of living marine organisms (algae, invertebrates, fishes, marine mammals, and shorebirds) and of the environment they inhabit. Fieldwork is emphasized. Occasional lectures and films deal with additional topics such as coastal-zone problems, marine fisheries, economics of marine organisms, and educational resources of the marine environment. The core faculty of marine biologists is augmented by specialists in science and environmental education. Dissection of vertebrate animals will be a part of one or more laboratory sessions.

364 Field Marine Science
Summer. 6 credits. Prerequisite: one year of college biology or other supporting subject. S-U grades optional. A special 4-week course offered twice each summer at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML Office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,975.

Daily lecs, labs, and fieldwork for 4 weeks. 3 core faculty members assisted by up to 15 visiting lecturers, including representatives of governmental agencies, and commercial fishermen. SML faculty.
Designed for the student who desires an initial overview of the marine sciences, this course emphasizes living material in natural habitats. Most of the course work is concerned with the biology of intertidal plants and animals, biological oceanography, ichthyology, and fisheries. Attention is also given to introductory physical and chemical oceanography and marine geology. Marine ecology and the effects of human activity on the marine environment are included. Dissection of vertebrate animals will be a part of one or more laboratory sessions.

365 Underwater Research
Summer. 2 credits. Prerequisites: one year of college-level biology or other supporting subject, recognized scuba certification, and a medical examination. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,250.

Daily lecs and fieldwork for 2 weeks. Team-taught by a diving-safety officer, two faculty members, and guest lecturers.
For competent divers only. Covers special problems of underwater research, including random sampling, use of dive tables, underwater instrumentation, special diving equipment, photographic techniques, integration with boat and shore facilities, and emergency procedures. Students are required to conduct a transect study on both soft and hard substrates.

366–370 SEA Semester
In cooperation with the Sea Education Association (SEA), the Shoals Marine Laboratory office offers a semester-length sequence of courses designed to provide college undergraduates with a thorough academic, scientific, and practical understanding of the sea. *This sequence is repeated approximately once every two months throughout the year.* Students spend the first half of SEA Semester (the six-week shore component) in Woods Hole, Massachusetts, receiving instruction in oceanography, nautical science, and maritime studies. The second half of SEA Semester (the six-week sea component) is spent at sea aboard R/V *Westward* or the R/V *Corwith Cramer*. Applicants are interviewed in Ithaca before

admission. Enrollment is open to men and women judged capable of benefiting from SEA Semester; no specific prior training or study is required. *Cornell students enrolled in the SEA Semester must take the entire sequence.*

For more details and an application, consult the Shoals Marine Laboratory office, G14 Stimson Hall. Program costs are to be paid in place of regular Cornell tuition and fees: tuition for entire 17-credit SEA Semester, about $6,200; room and board for sea component (six weeks) only, about $1,875.

Instructors for the SEA Semester include faculty of the Sea Education Association and the Woods Hole Oceanographic Institution and others.

Shore Component (six weeks)

366 SEA Introduction to Oceanography
3 credits. Prerequisites: a laboratory course in physical or biological science and concurrent enrollment in Biological Sciences 367 and 368. A survey of the characteristics and processes of the global ocean. Oceanographic concepts are introduced and developed from their bases in biology, physics, chemistry, and geology. Provides a broad background in oceanography with special attention to areas pertinent to the subsequent cruise. Guest lecturers from the Woods Hole research community interpret current trends and activities in this rapidly evolving field. Students develop individual projects to be carried out at sea.

367 SEA Introduction to Maritime Studies
3 credits. Prerequisite: concurrent enrollment in Biological Sciences 366 and 368.
An interdisciplinary consideration of our relationship with the marine environment. Covers the elements of maritime history, law, literature, and art necessary to appreciate our marine heritage and to understand the political and economic problems of contemporary maritime affairs.

368 SEA Introduction to Nautical Science
3 credits. Prerequisites: college algebra or equivalent, and concurrent enrollment in Biological Sciences 366 and 367. An introduction to the technologies of operation at sea. The concepts of navigation (piloting, celestial, and electronic), naval architecture, ship construction, marine engineering systems, and the physics of sail are taught from their bases in astronomy, mathematics, and physics. Provides the theoretical foundation for the navigation, seamanship, and engineering that students employ at sea.

Sea Component (six weeks)

Courses 369 and 370 take place aboard the R/V *Westward*, a 125-foot steel auxiliary-powered staysail schooner built in 1961, or the R/V *Corwith Cramer*, a 134-foot steel auxiliary-powered brigantine built in 1987 for SEA. Both ships normally put to sea with a ship's company of thirty-four. The professional staff of nine includes the captain, the chief scientist, two science watch officers, three deck watch officers, an engineer, and a steward. In addition, one or more visiting investigators are frequently aboard. Up to twenty-five students round out the complement.

369 SEA Practical Oceanography I
4 credits. Prerequisite: Biological Sciences 366. Theories and problems raised in the shore component are tested in the practice of oceanography at sea. Students are introduced to the tools and techniques of the practicing oceanographer. During lectures and watch standing, students are instructed in the operation of basic oceanographic equipment; in the methodologies involved in the collection, reduction, and analysis of oceanographic data; and in the attendant operations of a sailing oceanographic research vessel.

370 SEA Practical Oceanography II
4 credits. Prerequisite: Biological Sciences 368. Building on the experience of Practical Oceanography I, students assume increasing responsibility for conducting oceanographic research and overseeing operations of the vessel. The individual student is ultimately responsible directly to the chief scientist and the master of the vessel for the safe and orderly conduct of research activities and related operations of the vessel. Each student undertakes an individual research project designed during the shore component.

372 An Introduction to the Ecology and Chemistry of Rock-Pool Environments
Summer. 1 credit. Prerequisite: an introductory biology, chemistry, or marine science course at the college level or permission of instructor. S-U grades optional. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $675.
Daily lecs, labs, and fieldwork for 1 week. SML faculty.
A fundamental field-oriented introduction to the interrelationships of the chemistry and biology of both rock- and tide-pool ecosystems, using the numerous pools on Appledore Island as natural laboratories.

413 Adaptations of Marine Organisms
Summer. 4 credits. Prerequisite: Biological Sciences 364 or a course in physiological ecology. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,550.
Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.
An introduction to the physiological ecology and functional morphology of marine plants and animals, with emphasis on selected algal and invertebrate examples from the Gulf of Maine. Topics covered include photosynthesis in the marine environment; respiration in intertidal organisms; carbohydrates, proteins, and lipids as nutrients in the sea; acclimation and tolerance of tide-pool biota; and biological responses to competition and grazing. Field and laboratory exercises explore principles and procedures used to characterize the physical, chemical, and biotic environment of intertidal and shallow subtidal organisms, including determination of temperature, light, salinity, oxygen and nutrient levels, and *in vivo* functional analyses of metabolic phenomena. Dissection of vertebrate animals will be a part of one or more laboratory sessions.

449 Marine Botany: Ecology of Marine Plants
Summer. 2 credits. Prerequisite: Biological Sciences 364 or general familiarity with marine algae. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,100.
Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.
An overview of the major marine algal groups, including aspects of anatomy, morphology, development, life histories, physiology, and use. Laboratories and fieldwork emphasize relationships between distribution and major environmental parameters and involve student projects.

466 Ecology and Chemistry of Rock-Pool Environments
Summer. 4 credits. Prerequisites: one year of introductory college chemistry and an introductory ecology course at the college level. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,550.
Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.
A field-oriented course emphasizing the interrelationships of the chemistry and biology of both rock- and tide-pool ecosystems, using the numerous pools on the island as natural laboratories. Laboratory work includes organism identification; chemical analyses of pools for nutrients, pH, alkalinity, dissolved carbon dioxide and oxygen, salinity, plant pigments, and primary production; and determinations of lethal temperature, salinity, and oxygen level for different species and populations. Lectures and class research projects cover the effects of pool morphology and algal growth on pool temperature, chemistry, and stratification; salinity changes caused by evaporation, rainfall, and seawater splash; dissolved oxygen and pH changes associated with primary production; nutrient dynamics relative to rainfall, flow through, primary production, microbial activities, and proximity to nesting birds; primary production differences among pool types; and predation experiments with fish implantation. Food web and energy models for different rock-pool ecosystems are presented. The use of microcomputers for interpretation of data is emphasized.

467 Chemical Oceanography of Coastal Waters
Summer. 4 credits. Prerequisites: one year of introductory college chemistry and an introductory marine science course at the college level. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,550.
Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.
A field-oriented course in the chemical oceanography of coastal waters. Lectures, frequent field trips, and laboratory sampling

and analysis; includes tests of salinity, temperature, pH, chlorophyll, alkalinity, total CO2, nutrients, organic material, and suspended materials in coastal waters, with some work on the analysis of coastal sediments.

468 Marine Plankton Ecology
Summer. 2 credits. Limited to 20 students. Prerequisites: one year of introductory college biology and Biological Sciences 364 or equivalent, or a course in invertebrate zoology or introductory oceanography. S-U grades optional. A special course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,100.

Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

An introduction to the biology of plankton and their ecological role in representative marine environments, including estuaries, coastal areas, open ocean gyres, and polar seas. Includes an overview of morphology, life histories, and nutrition of planktonic bacteria, protozoans, algae, and metazoans (coelenterates, crustaceans, ctenophores, chaetognaths, and tunicates). The role of these groups in different ecosystems is related to the hydrography of the area, as well as the life cycles and trophic interactions of the dominant species. During several one-day cruises in the Gulf of Maine and Great Bay Estuary students use simple field techniques to address current research problems.

477 Marine Vertebrates
Summer. 4 credits. Prerequisite: Biological Sciences 364 or 274 or a course in vertebrate biology. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,550.

Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

Topics in marine vertebrate biology emphasizing laboratory studies, field collections or observations, and readings from the current literature. Topics covered include systematics of fishes of the Gulf of Maine, elasmobranch physiology, interpretation of life history and parameters from otolith microstructure, teleost skeletomuscular structure and function, population biology and the contemporary Gulf of Maine fishery, Mesozoic marine reptiles, the biology of sea turtles in cold water, coloniality in sea birds, avian adaptations to life at sea, evolution and systematics of marine mammals, diving physiology, and ecology and conservation of existing marine mammal populations. Dissection of vertebrate animals is a part of one or more laboratory sessions.

488 Reproduction and Development of Marine Invertebrates
Summer. 4 credits. Prerequisite: Biological Sciences 364 or a course in invertebrate zoology. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,550.

Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

A laboratory-oriented course emphasizing processes of fertilization and early development through the metamorphosis of larvae in species selected from an extensive variety of local marine invertebrates. Practical experience includes collecting specimens intertidally and from the plankton, culturing embryos through metamorphosis, camera lucida and photomicrographic recording of embryonic development, and design and execution of basic experiments on eggs and embryos. Lectures complement laboratory work through phylogenetic examination of classical invertebrate embryology and modern experimental developmental biology.

Archaeology of Maritime Communities (Archaeology 300: Individual Study in Archaeology)
Summer. 1 credit. Prerequisite: Archaeology 319 or permission of instructor. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $675.

Daily lecs, labs, and fieldwork for 1 week. SML faculty.

Fieldwork on various land sites and their adjacent offshore marine environments. Artifact analysis, preliminary conservation, and the proper recording of finds are emphasized. Methods of archaeological research, including the use of archives and historical materials, and publication methodologies as well as the larger questions in the discipline are discussed.

Coastal and Oceanic Law and Policy (Natural Resources 306)
Summer. 1 credit. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $675.

Daily lecs and discs for 1 week. SML faculty.

Intended for persons interested in careers in management of marine or coastal resources or in the natural sciences. Subjects include law and policy related to ocean dumping, marine sanctuaries, environmental impact statements, water and air pollution, fisheries management, offshore gas and oil production, and territorial jurisdiction. Lectures on the status and history of law are accompanied by discussion of relevant policy and analysis of the efficacy of various legal techniques. A case study that requires extensive use of the laboratory's library and personnel is assigned. The week concludes with a mock hearing.

Marine Pollution (Agricultural Engineering 420)
Summer 2 credits. Prerequisite: Biological Sciences 364 or permission of instructor. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $975.

Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

Dispersion modeling and the effects of pollutants (including oil, outfalls, solid wastes, sludge and dredge spoils, and radioactive wastes) are discussed from the perspectives of elementary physical oceanography and biological processes. Laboratories include basic methods for targeting and tracing wastewater; organic carbon determinations; and practical field projects.

Marine and Coastal Geology (Geological Sciences 213)
Summer. 1 credit. Prerequisite: an introductory course in geology or permission of instructor. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $675.

Daily lecs, labs, and fieldwork for 1-week. SML faculty.

With "the New England coast" defined as beginning at the -200 meter isobath and proceeding westward, this course examines specific geological events and processes important in shaping the area's bedrock and surficial sediments. Petrology, geophysics, and the Pleistocene geology of the region are investigated. Consideration of the geologic history of New England within the plate tectonic model is emphasized. Examination of insular geology is used to integrate micro-, meso-, and macroscale geological evolution of continental margins in general. Marine geology is approached through basic geophysical exploration and bottom-sediment collection followed by data analysis and interpretation. Experience aboard a coastal research vessel is an integral part of the course.

Marine Resources: Economic Modeling of Use and Regulation (Agricultural Economics 252)
Summer. 1 credit. Prerequisite: an introductory course in economics or permission of instructor. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $675.

Daily lecs and discs for 1 week. SML faculty.

Resource economics in general is concerned with the optimal allocations through time of renewable and nonrenewable resources. This course examines fisheries management, offshore oil and gas recovery, and ocean-minerals mining. Models of optimal resource use are developed and used to assess both the behavior of those harvesting marine resources and the adequacy of current governmental policy. An integral part of the course is the special opportunity to observe and interview those professionally involved in harvesting marine resources in the Gulf of Maine.

Archaeology Underwater (Archaeology 319)
Summer. 1 credit. Prerequisites: recognized scuba certification and a medical examination required for students engaging in underwater research. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $700.

Daily lecs, labs, and fieldwork for 1 week. SML faculty.

An introduction to the subject and a review of this contemporary subdiscipline of archaeology. The approach of the course is practical, with a strong potential for actual on-site experience in search, site recognition, survey, and recording. The course also covers the history and development of the subject, the legal aspects of underwater research, and the worldwide potential of the field. Since any archaeological research project involves a great deal more than digging, the course provides ample opportunities for those who are interested in the subject but are not divers or sufficiently experienced in scuba.

Wetland Resources (Natural Resources 417)

Summer. 1 credit. Prerequisite: one year of college biology. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $675.

Daily lecs, labs, and fieldwork for 1 week. SML faculty.

An examination of coastal and adjacent freshwater wetlands from historic, destruction, and preservation perspectives, including fresh- and salt-marsh ecology and management. Field trips to selected examples of the wetlands under discussion and follow-up laboratories emphasize successional features, plant identification and classification, and examination of the dominant insect and vertebrate associations.

COURSES IN BIOPHYSICS

Biophysics is an interdisciplinary undergraduate and graduate program. A special program for undergraduate students interested in biophysics is offered as an independent concentration (program of study) in the biological sciences major (see option 8 under "Concentration Areas and Requirements" and option 9 under "Programs of Study"). Information on this independent option is available in the Office for Academic Affairs, 118 Stimson Hall. Students interested in graduate work in biophysics should inquire at the Program in Biophysics Office, 210 Clark Hall.

The following courses are available for students interested in biophysics:

Biomechanical Systems—Analysis and Design (Mechanical and Aerospace Engineering 565)

Chemistry of Nucleic Acids (Chemistry 677)

Electron Microscopy for Biologists (Biological Sciences 401, 403, 405, 606, 608)

Enzyme Catalysis and Regulation (Chemistry 672)

Membrane Biophysics (Applied and Engineering Physics 615)

Membranes and Bioenergetics (Biological Sciences 632)

Neuroethology (Biological Sciences 424)

Photosynthesis (Biological Sciences 445)

Physical Chemistry of Proteins (Chemistry 686)

Principles of Neurophysiology (Biological Sciences 491)

Protein Structure and Function (Biological Sciences 631)

Special Topics in Biophysical and Bioorganic Chemistry (Chemistry 782)

Transport of Solutes and Water in Plants (Biological Sciences 649)

FACULTY ROSTER

New York State College of Agriculture and Life Sciences

Adler, Kraig K., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior

Bates, David M., Ph.D., U. of California at Los Angeles. Prof., Bailey Hortorium

Beyenbach, Klaus W., Ph.D., Washington State U. Prof., Physiology/Veterinary Physiology†

Bruns, Peter J., Ph.D., U. of Illinois. Prof., Genetics and Development

Calvo, Joseph M., Ph.D., Washington State U. William T. Keeton Professor in Biological Sciences; Biochemistry, Molecular and Cell Biology

Davies, Peter J., Ph.D., U. of Reading (England). Prof., Plant Biology

Davis, Jerrold I., Ph.D., U. of Washington. Asst. Prof., Bailey Hortorium

Doyle, Jeffrey J., Ph.D., Indiana U. Asst. Prof., Bailey Hortorium

Eisner, Thomas, Ph.D., Harvard U. Jacob Gould Schurman Professor, Neurobiology and Behavior

Emlen, Stephen T., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior

Feeny, Paul P., Ph.D., Oxford U. (England). Prof., Ecology and Systematics/Entomology*

Fox, Thomas D., Ph.D., Harvard U. Assoc. Prof., Genetics and Development

Gibson, Jane, Ph.D., U. of London (England). Prof., Biochemistry, Molecular and Cell Biology

Goldberg, Michael L., Ph.D., Stanford U. Assoc. Prof., Genetics and Development

Hanson, Maureen R., Ph.D., Harvard U. Assoc. Prof., Genetics and Development

Harrison, Richard G., Ph.D., Cornell U. Assoc. Prof., Ecology and Systematics

Harris-Warrick, Ronald M., Ph.D., Stanford U. Assoc. Prof., Neurobiology and Behavior

Harvell, C. Drew, Ph.D., U. of Washington. Asst. Prof., Ecology and Systematics

Hopkins, Carl D., Ph.D., Rockefeller U. Prof., Neurobiology and Behavior

Jagendorf, Andre T., Ph.D., Yale U. Liberty Hyde Bailey Professor of Plant Physiology, Plant Biology*

Keller, Elizabeth B., Ph.D., Cornell U. Prof., Biochemistry, Molecular and Cell Biology

Kemphues, Kenneth J., Ph.D., Indiana U. Asst. Prof., Genetics and Development

Lis, John T., Ph.D., Brandeis U. Assoc. Prof., Biochemistry, Molecular and Cell Biology

Loew, Ellis R., Ph.D., U. of California at Los Angeles. Assoc. Prof., Physiology/Veterinary Physiology†

Luckow, Melissa A., Ph.D., U. of Texas at Austin. Asst. Prof., Bailey Hortorium

McCarty, Richard E., Ph.D., Johns Hopkins U. Prof., Biochemistry, Molecular and Cell Biology

McCune, Amy R., Ph.D., Yale U. Asst. Prof., Ecology and Systematics

MacIntyre, Ross J., Ph.D., Johns Hopkins U. Prof., Genetics and Development*

Marks, Peter L., Ph.D., Yale U. Prof., Ecology and Systematics

Moffat, J. Keith, Ph.D., Cambridge U. (England). Prof., Biochemistry, Molecular and Cell Biology

Nasrallah, June B., Ph.D., Cornell U. Asst. Prof., Plant Biology

Niklas, Karl J., Ph.D., U. of Illinois. Prof., Plant Biology/Ecology and Systematics

Nixon, Kevin C., Ph.D., U. of Texas at Austin. Asst. Prof., Bailey Hortorium

Owens,Thomas G.,Ph.D., Cornell U. Asst. Prof., Plant Biology

Paolillo, Dominick J., Jr., Ph.D., U. of California at Davis. Prof., Plant Biology

Parthasarathy, Mandayam V., Ph.D., Cornell U. Prof., Plant Biology

Pough, F. Harvey, Ph.D., U. of California at Los Angeles. Prof., Ecology and Systematics/Physiology

Quaroni, Andrea, Ph.D., U. of Pavia (Italy). Asst. Prof., Physiology

Roberts, Jeffrey W., Ph.D., Harvard U. Prof., Biochemistry, Molecular and Cell Biology*

Root, Richard B., Ph.D., U. of California at Berkeley. Prof., Ecology and Systematics/Entomology

Spanswick, Roger M., Ph.D., U. of Edinburgh (Scotland). Prof., Plant Biology

Tye, Bik-Kwoon, Ph.D., Massachusetts Inst. of Technology. Assoc. Prof., Biochemistry, Molecular and Cell Biology

Vogt, Volker M., Ph.D., Harvard U. Assoc. Prof., Biochemistry, Molecular and Cell Biology

Walcott, Charles, Ph.D., Cornell U. Prof., Neurobiology and Behavior/Laboratory of Ornithology

Wayne, Randy O., Ph.D., U. of Massachusetts. Asst. Prof., Plant Biology

Winkler, David W., Ph.D., U. of California at Berkeley. Asst. Prof., Ecology and Systematics

Wu, Ray, Ph.D., U. of Pennsylvania. Prof., Biochemistry, Molecular and Cell Biology

Zahler, Stanley A., Ph.D., U. of Chicago. Prof., Genetics and Development

Other Teaching Personnel

Alexander, Renee R., Ph.D., Cornell U. Sr. Lecturer, Biochemistry, Molecular and Cell Biology

Calvo, Rita A., Ph.D., Cornell U. Lecturer, Genetics and Development

Ecklund, P. Richard, Ph.D., Oregon State U. Lecturer, Neurobiology and Behavior

Ferger, Martha F., Ph.D., Cornell U. Medical College. Sr. Lecturer, Biochemistry, Molecular and Cell Biology

Glase, Jon C., Ph.D., Cornell U. Sr. Lecturer, Neurobiology and Behavior

Griffiths, Joan M., Ph.D., Cornell U. Lecturer, Biochemistry, Molecular and Cell Biology

Heiser, John B., Ph.D., Cornell U. Sr. Lecturer, Ecology and Systematics

McFadden, Carol H., Ph.D., Cornell U. Sr. Lecturer, Physiology

Reiss, H. Carol, M.S., Cornell U. Lecturer, Plant Biology

Joint Appointees

Barker, Robert, Prof., Provost's Office/Biochemistry, Molecular and Cell Biology

Bedford, Barbara L., Adjunct Asst. Prof., Ecosystems Research Center/Ecology and Systematics

Bloom, Stephen E., Assoc. Prof., Poultry and Avian Sciences/Biological Sciences
Borror, Arthur C., Adjunct Prof., U. of New Hampshire/Biological Sciences
Brown, William L., Jr., Prof., Entomology/Ecology and Systematics
Butler, Walter R., Assoc. Prof., Animal Science/Physiology
Currie, W. Bruce, Assoc. Prof., Animal Science/Physiology
Edelestein, Stuart M., Adjunct Prof., U. of Geneva (Switzerland)/Biochemistry, Molecular and Cell Biology
Foote, Robert H., Jacob Gould Schurman Professor, Animal Science/Physiology
Howell, Stephen H., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Kochian, Leon V., Adjunct Asst. Prof., USDA Science and Education Administration/Plant Biology
Korf, Richard P., Prof., Plant Pathology/Bailey Hortorium
LaRue, Thomas A., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Leopold, A. Carl, Adjunct Prof., Boyce Thompson Institute/Plant Biology
Pimentel, David, Prof., Entomology/Ecology and Systematics
Richmond, Milo E., Assoc. Prof., USDI Fish and Wildlife Service/Natural Resources/Ecology and Systematics
Tamas, Imre A., Adjunct Assoc. Prof., Ithaca College/Plant Biology
Thompson, John F., Adjunct Prof., USDA Science and Education Administration/Plant Biology
Via, Sara, Asst. Prof., Entomology/Ecology and Systematics
Weeden, Norman F., Asst. Prof., Horticultural Sciences/Bailey Hortorium
Wheeler, Quentin D., Assoc. Prof., Entomology/Bailey Hortorium

College of Arts and Sciences

Aquadro, Charles F., Ph.D., U. of Georgia. Assoc. Prof., Genetics and Development/Ecology and Systematics
Bass, Andrew H., Ph.D., U. of Michigan. Asst. Prof., Neurobiology and Behavior
Blackler, Antonie W., Ph.D., U. of London (England). Prof., Genetics and Development
Booker, Ronald, Ph.D., Princeton U. Asst. Prof., Neurobiology and Behavior
Bretscher, Anthony P., Ph.D., Leeds U. (England). Assoc. Prof., Biochemistry, Molecular and Cell Biology
Brown, William J., Ph.D., U. of Texas Health Science Center at Dallas. Asst. Prof., Biochemistry, Molecular and Cell Biology
Capranica, Robert R., Sc.D., Massachusetts Inst. of Technology. Prof., Neurobiology and Behavior
Chabot, Brian F., Ph.D., Duke U. Prof., Ecology and Systematics‡
Feigenson, Gerald W., Ph.D., California Inst. of Technology. Assoc. Prof., Biochemistry, Molecular and Cell Biology
Gibson, Quentin H., Ph.D./D.Sc., Queen's U. (Northern Ireland). Greater Philadelphia Professor in Biological Sciences; Biochemistry, Molecular and Cell Biology
Hairston, Nelson G., Jr., Ph.D., U. of Washington. Prof., Ecology and Systematics
Halpern, Bruce P., Ph.D., Brown U. Prof., Neurobiology and Behavior/Psychology
Hamill, Owen P., Ph.D., U. of New South Wales (Australia). Asst. Prof., Neurobiology and Behavior
Heppel, Leon A., Ph.D., U. of California at Berkeley. Prof., Biochemistry, Molecular and Cell Biology
Hess, George P., Ph.D., U. of California at Berkeley. Prof., Biochemistry, Molecular and Cell Biology
Hinkle, Peter C., Ph.D., New York U. Prof., Biochemistry, Molecular and Cell Biology
Howarth, Robert W., Ph.D., Massachusetts Inst. of Technology/Woods Hole Oceanographic Institution. Assoc. Prof., Ecology and Systematics
Howland, Howard C., Ph.D., Cornell U. Prof., Neurobiology and Behavior/Physiology
Hoy, Ronald R., Ph.D., Stanford U. Prof., Neurobiology and Behavior‡
Huffaker, Tim C., Ph.D., Massachusetts Inst. of Technology. Asst. Prof., Biochemistry, Molecular and Cell Biology
Karplus, Paul A., Ph.D., U. of Washington. Asst. Prof., Biochemistry, Molecular and Cell Biology
Kennedy, Kenneth A.R., Ph.D., U. of California at Berkeley. Prof., Ecology and Systematics
Levin, Simon A., Ph.D., U. of Maryland at College Park. Charles A. Alexander Professor of Biological Sciences; Ecology and Systematics‡
McClearn, Deedra K., Ph.D., Harvard U. Asst. Prof., Ecology and Systematics
MacDonald, June M. Fessenden, Ph.D., Tufts U. Assoc. Prof., Biochemistry, Molecular and Cell Biology/Program on Science, Technology, and Society
Mark, Willie H., Ph.D., U. of Wisconsin—Madison. Asst. Prof., Genetics and Development
Podleski, Thomas R., Ph.D., Columbia U. Prof., Neurobiology and Behavior‡
Power, Alison G., Ph.D., U. of Washington. Asst. Prof., Ecology and Systematics/Program on Science, Technology, and Society
Provine, William B., Ph.D., U. of Chicago. Prof., Ecology and Systematics/History
Racker, Efraim, M.D., U. of Vienna (Austria). Albert Einstein Professor of Biochemistry; Biochemistry, Molecular and Cell Biology
Salpeter, Miriam M., Ph.D., Cornell U. Prof., Neurobiology and Behavior/Applied and Engineering Physics§
Schneiderman, Anne M., Ph.D., Harvard U. Asst. Prof. Neurobiology and Behavior
Seeley, Thomas D., Ph.D., Harvard U. Assoc. Prof., Neurobiology and Behavior
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Dobson Alan, Prof., Veterinary Physiology/Physiology
Houpt, Katherine A., Prof., Veterinary Physiology/Physiology
Houpt, T. Richard, Prof., Veterinary Physiology/Physiology
Kallfelz, Francis A., Prof., Clinical Sciences/Veterinary Physiology/Physiology
Nathanielsz, Peter W., Leading Prof., Clinical Sciences/Veterinary Physiology/Physiology
Wootton, John F., Prof., Veterinary Physiology/Physiology

College of Engineering

Joint Appointee

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Webb, Watt W., Prof., Applied and Engineering Physics/Biological Sciences

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Division of Nutritional Sciences

Joint Appointees

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Bensadoun, Andre, Prof., Nutritional Sciences/Physiology
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Watford, Malcolm, Asst. Prof., Nutritional Sciences/Biochemistry, Molecular and Cell Biology
Zilversmit, Donald B., Prof., Nutritional Sciences/Biochemistry, Molecular and Cell Biology

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†Joint appointment with the College of Veterinary Medicine.
‡Joint appointment with the College of Agriculture and Life Sciences.
§Joint appointment with the College of Engineering.